US Army Corps of Engineers ®

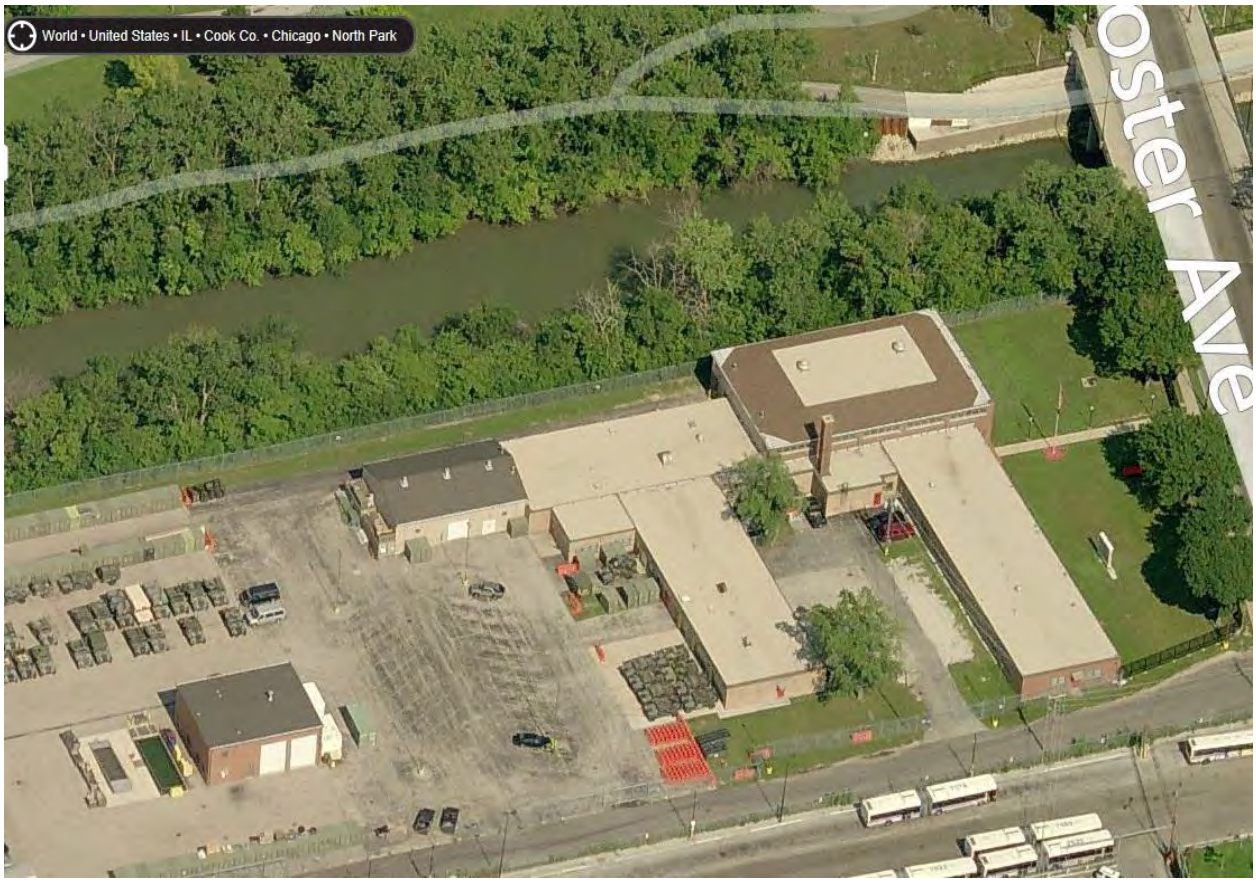
Design Analysis – Final, For Construction

Solar Photo Voltaic (PV) Systems

in Support of Marine Force Reserves (MFR) Sites

Project Number: 541320
Chicago, Illinois

August 2014



BLAIRREMY ARCHITECTS

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TABLE OF CONTENTS

Chapter – I General

Chapter – II Siting (Not Used)

Chapter – III Site Development (Not Used)

Chapter – IV Landscaping Irrigation Plantings (Not Used)

Chapter – V Utilities (Not Used)

Chapter – VI Anti Terrorism Force Protection (Not Used)

Chapter – VII Architectural

Chapter – VIII Structural

Chapter – IX Mechanical (Not Used)
IX-1 HVAC (Not Used)
IX-2 Plumbing (Not Used)
IX-3 Fire Protection (Not Used)

Chapter – X Electrical

Chapter – XI Electronics (Not Used)
XI-1 Electronic Systems (Not Used)
XI-2 Communications (Not Used)

Chapter – XII Foundation Conditions (Not Used)

Chapter – XIII Sustainable Design Development (Not Used)

Appendices:

Appendix – A PV System Site Survey Info Report
Appendix – B Annotated Design Review Comments
Appendix – C Structural Calculations and Cut Sheets
Appendix – D PV System – Shadow Analysis/Site Plan
Appendix – E Electrical Calculations and Cut Sheets
Appendix – F Fall Protection

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Chapter – I General

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Chapter I General

Design Analysis
Solar Photo-Voltaic (PV) Systems
in Support of Marine Force Reserves (MARFORRES)
Chicago, Illinois

1. General Description:

The Marine Forces Reserve Facility will receive photo-voltaic panels on approximately 12,470 SF of the existing roof. The A/E team recommends repairs or replacement to the entire existing roofing system for the Main Reserve Center building. The A/E team is concerned about adding a long term photovoltaic system to a roof that appears to be at the end of its lifecycle. Repairs to the high sloped roofs with standing seam metal roofing material are not required.

2. Design Analysis Sections

This Design Analysis reflects Blair Remy's interpretation of criteria contained in the Statement of Work for A-E Services for Photo-Voltaic System Designs at Marine Forces Reserve (MARFORRES) located in Chicago, Illinois.

Included in this document are discipline narratives addressing:

- Structural Engineering
- Architectural
- Electrical Engineering

3. Building Demolition

The existing buildings with low sloped roofs will require removal of all roofing materials.

4. Project Schedule:

Following is the projected project schedule:

- 30 May 2014 – 35% Design, Analysis Specifications for Govt. Review
- 15 August 2014 - 95% Design, Analysis Specifications for Govt. Review
- 15 August 2014 - Final Package

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Chapter – VII Architectural

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Chapter VII Architectural

Design Analysis
Solar Photo-Voltaic (PV) Systems
in Support of Marine Force Reserves (MARFORRES)
Chicago, Illinois

1. Design References:

a. International Building Code – 2012 Edition

b. NFPA 101, Life Safety Code – 2010 Edition

c. NFPA 220, Standard on Types of Building Construction – 2009 Edition

d. TI-800-01, Design Criteria

e. MIL-HDBK-1190, Facility Design Manual

f. UFC 3-110, Design: Architecture

g. AFI 32-1084, Standard Facilities Requirements Handbook

h. ABA, Architectural Barriers Act

i. OSHA, Occupational Safety and Health Administration Guidelines

2. General Descriptions of the Project:

The project is to install a Solar Photo-Voltaic (PV) System on the roof structure at the existing facility. The intent of this action is to fulfill the requirements of the National Defense Authorization Act of 2007 and Executive Order 13423 regarding renewable energy requirements (25% renewable by 2025). The A/E team recommends the removal of the existing gravel ballast and modified bitumen roofing material on all low sloped roofs, and replace with a new roof. The A/E team suggests replacing the modified bitumen roofs because they appear to be at the end of their lifecycle. On a later site visit, Blair Remy's structural engineering consultant observed the roof being replaced. Refer to structural documents.

3. Basis of Design Summary:

The Photo-Voltaic System will be designed with evaluations of the site, needs of the user, and budget limitations. The project is an installation of an 88 kW photovoltaic system. A suitable location for the PV array will be determined by shading patterns and building orientation. Because of site limitations, PV panels are only considered feasible on the roofs. PV panels installed on low sloped roofs will be attached to a molded polyethylene base. The layout of PV panels will be designed around obstructions such as antennas, plumbing and mechanical vents.

Fall Protection during installation shall be a part of the means and methods of construction and fall under the responsibility of the contractor. A permanent Fall Protection system is beyond the Scope of the project. However, the A/E team recommends Fall Protection during the maintenance of the photovoltaic system throughout its life cycle. In order to avoid direct attachment to the structural systems, and penetrating the existing roofing material, we suggest the following. For low sloped roofs consider a non-penetrating anchor such as the Freestanding Counterweight Anchor from Capital Safety, Brand: DBI-SALA, Model: 7255000. For high sloped roofs consider the Miller Fusion Roof Anchor, Model: SKU X10001 or Model: SKU X10011. See Appendix – F Fall Protection, for more information.

The A/E team recommends placing photovoltaic panels on the existing roof structures. The structure will be reinforced or braced if the additional loads caused by the PV panels require it. Refer to structural documents for structural access requirements and methods of reinforcement. Visual access to the roof structure is above the ceiling tiles on the low sloped flat roofs. All light fixtures and HVAC components directly under the structure to be reinforced, will be supported, secured, or removed. The contractor will store and replace building components as required to perform the work.

Refer to Chapter VIII Structural for additional information.

Chapter – VIII Structural

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Chapter VIII Structural

Design Analysis
Solar Photo-Voltaic (PV) Systems
in Support of Marine Force Reserves (MARFORRES)
Chicago, Illinois

1. Design References:

a. 2012 International Building Code

b. ACI 318-11, Building Code Requirements for Reinforced Concrete

c. AISC Manual of Steel Construction, Load and Resistance Factor Design, 14th Edition

d. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures

e. ACI 530.1-08, Building Code Requirements for Masonry Structures

f. SDI Pub No 29, Steel Deck Institute Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Metal Floor Deck With Electrical Distribution

g. UFC 1-200-01 (1 July 2013), Unified Facilities Criteria, Design: General Building Requirements

h. UFC 3-301-01 (1 June 2013), Unified Facilities Criteria, Design: Structural Engineering

i. UFC 4-010-01 (9 February 2012 including change 1, 1 October, 2013), Unified Facilities Criteria, DoD Minimum Antiterrorism Standards for Buildings

j. UFC 4-023-03 (14 July 2009), Unified Facilities Criteria, Design of Buildings to Resist Progressive Collapse

2. General Description:

The site PV installation involves installing a PV panel system and associated hardware to several buildings at the West Foster Ave. MARFORRES site in Chicago, IL. This requires the evaluation of the existing roof framing system for the Main Reserve Center buildings, and determination of their adequacy as load-supporting systems under the new dead and wind loads associated with the PV systems. There are essentially two framing systems for the Main Reserve Center. The flat roof buildings were being re-roofed during our site visit, appearing to be a layered system of modified bitumen and ballast. The flat-panel concrete roof deck and concrete beams are bearing on cmu/brick exterior walls and cmu interior walls, with a relative standard deck span of 12’-0” to 13’-3” and a bearing height of 10 ft. Based upon our observations, these buildings were constructed in the early to mid 1950’s. We expect the design criteria for building design was the Uniform Building Code. The Drill area roof framing is sloped in the core, approximately 3:12, with windows around the center raised roof. Framing is of structural steel rigid-frames with bar joists spaced 6’-0” c/c supporting a metal roof deck.

3. Lateral Stability

The PV system placement on drill area sloped roof will create an increased lateral force on the existing lateral force-resisting system. The PV system placement on the flat roof areas of the Main Reserve Center will not exceed original design of 20 psf live load and will supercede the inclusion of live load in loading combinations with PV panel loads.

4. Progressive Collapse

Progressive collapse is a consideration in cases where a structure requiring progressive collapse analysis for its original design is now loaded with new dead loads at the roof, which increase the loads on redundant members using the alternate path and/or tie force methods.

5. Foundations

Existing foundations are less of a concern than the smaller framing at the roof. Typically, foundations will have some excess capacity, and the load increase due to the panels will be modest.

6. Design Loads

a. Roof Live Load	20 psf where no PV panels PV Panels and Hardware: 4 psf
b. Floor Live Loads	N/A
c. Wind Load	115 mph (Risk Cat. II)
d. Seismic	S_S = 0.16g; S_1 = 0.06g
e. Snow	25 psf Ground Snow Load

7. Materials

a. Concrete, typical	N/A
b. Reinforcing Steel	N/A
c. Mortar	N/A
d. Cold Formed Steel	N/A
e. Structural Steel	ASTM A992 (Wide Flanges) ASTM A500 Grade B (HSS Shapes) ASTM A50 (all other shapes)

8. Specifications

Refer to Specifications

9. Calculations

See Appendix C – Structural Calculations

Chapter – X Electrical

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Chapter X Electrical
Solar Photo Voltaic (PV) Systems
In Support of Marine Force Reserves (MARFORRES) Sites
Chicago, IL

1. Design References:

   The most recent edition of referenced publications applies unless otherwise specified:

   a. IEEE 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems,

   b. NFPA 70, National Electrical Code

   c. UFC 3-501-01 Electrical Engineering

   d. UFC 3-520-01 Interior Electrical Systems

   e. Energy Policy Act of 2005 (EPACT 2005)

2. General Description:

   The site PV installation involves installing a 88KW DC Rated PV system, which will involve installing PV Modules on existing flat roofs as well as one side of a pitched roof. The power generated from these modules will then be distributed back into the buildings electrical system at the main distribution panel located in the main electrical/mechanical room. AT present time the design includes 320, 275W DC rated modules for a combined output total of 88KW.

3. Exterior Electrical Distribution:

   The existing exterior medium voltage electrical distribution will not be reworked for this project.

4. Facility Electrical Power System:

   The facilities power distribution system is divided into the following systems:

   a. Normal Power Distribution:

   The existing power system will be modified for this project. New PV combiner circuit breaker panels are provided along with a main distribution circuit breaker panel as well as PV Modules, micro inverters, and racking for this project. The main tie in will be on the line side of the main disconnect for the building.

   b. Emergency Life Safety Power Distribution

   Not applicable for this project

   c. Emergency Power Distribution

   Not applicable for this project

   d. Critical Power Distribution

   Not applicable for this project

5. Interior Lighting:

   Not applicable for this project

6. Lightning Protection System (LPS):

a. A lightning protection system risk assessment was completed and it stated that a lightning protection system should be installed. The Design for the PV system currently does not show lightning protection system.

7. Energy and Management Control System:

   The existing EMCS system will not be modified for this project.

8. Intended User Responsibility for O&M:

   a. Not applicable for this project.

9. Service Responsibility:

   a. Exterior medium voltage electrical distribution: Not applicable at this time

   b. Interior electrical distribution: Interior facilities provided include the solar panels and racking, main PV combiner panels, PV distribution panel, and dry type transformer.

10. Design Provisions for O&M Enhancement and Cost Reduction:

   a. Access: Code recommended working space for maintenance is provided for all electrical equipment installed.

11. Basic Materials of Construction:

   a. All conductors are copper with THHN/THWN-2, 90 degrees C rated insulation. Minimum size #10.

   b. All conduit is EMT. Minimum conduit size is 3/4-inch.

   c. All exterior electrical equipment is NEMA 3R construction. Except boxes on the roof will be rated NEMA 4X minimum.

   d. All electrical equipment and panelboards utilize copper buses. All circuit breaker sizes less than 400 amperes are 80% rated and all sizes 400 amperes and larger are 100% rated and equipped with solid state trip devices.

   e. Communications cabling comprises plenum rated cables. All data and telephone cabling is Cat-6 solid copper.

   f. Electrical equipment and materials are generically specified using functional or descriptive specifications to avoid using “Brand” or “Manufacturer’s” names unless an “approved equal” designation is included to indicate quality and performance requirements where a “Brand” or “Manufacturer” is used as a Basis of Design.

12.Specifications:

Refer to Specifications List

13.Calculations:

Refer to Electrical Appendix for designer reports.

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Appendix – A PV System Site Survey Info Report

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Photo-Voltaic (PV) Systems

MARFORRES

Chicago, IL

Prepared for:

US Army Corps of Engineers
Fort Worth District

Prepared by:

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MARCH 2014

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 3

2. PROJECT LOCATION AND FIELD VISIT SCHEDULE 3

2.1. Project Location 3

2.2. Field Visit Schedule 3

3. FIELD VISIT NOTES 3

3.1. Field Visit Attendee List 3

3.2. General Meeting Notes 3

4. CIVIL/SITE OBSERVATIONS 4

4.1. General Observations 4

4.2. Site Access and Layout 4

4.3. Site Constraints 5

5. ARCHITECTURAL OBSERVATIONS 5

5.1. General Observations 5

5.2. Roof Observations (Architectural) 5

5.3. Limited Floor Plan Observation 7

6. ELECTRICAL OBSERVATIONS 7

6.1. General Observations 7

6.2. Roof Observations (Electrical) 7

6.3. Electrical Room 7

6.4. Limitations 8

7. STRUCTURAL OBSERVATIONS 8

8. CHALLENGES 8

8.1. Architectural Challenges 8

8.2. Electrical Challenges 8

9. RECOMMENDATIONS 8

9.1. General Recommendations 8

1. EXECUTIVE SUMMARY

The Corps of Engineers (Fort Worth District) has retained A/E Services from Blair Remy Corporation for Solar Photo Voltaic (PV) Systems design for MARFORRES Site in Chicago, IL. The PV System project includes a design of 150 kW Solar PV System installation on existing facilities at the site in support of fulfilling the requirements of the National Defense Authorization Act of 2007 and Executive Order 13423 regarding renewable energy requirements (25% renewable by 2025).

2. PROJECT LOCATION AND FIELD VISIT SCHEDULE

2.1. Project Location

Marine Force Reserves site at Chicago, IL.

2.2. Field Visit Schedule

The site visit for field survey was conducted on 27 March 2014.

3. FIELD VISIT NOTES

3.1. Field Visit Attendee List

NAME	PHONE	EMAIL
Bernard Braddick	(405) 340-9503	bbraddick@blairremy.com
Judd Oakes	(678) 281-0907	Judd.Oakes@merrick.com

3.2. General Meeting Notes

The PV systems site visit was conducted during typical business hours on Thursday, 27 March 2014. Weather conditions were cold, approximately 35-40 degrees, and overcast with continuous freezing rain.

The A/E Survey Team was comprised of Bernard Braddick with Blair Remy and Judd Oakes with Merrick, the architectural and electrical engineering representatives, respectively.

The A/E survey team was able to enter all spaces considered for PV panel installation. The A/E team viewed the roofs of the VMF (vehicle maintenance facility), and addition to the Reserve Center from the ground. The Main Reserve Center was viewed from the roof top. As-built and shop drawings for the existing structural systems were requested; however, none were available on site.

4. CIVIL/SITE OBSERVATIONS

4.1. General Observations

Possible laydown areas include all southern facing roof pitches and the low sloped flat roofs. Constructing covered parking areas to support photovoltaic panels in the northern parking lots to the rear of the base is not the best option, because this area is utilized by semi-trucks, military vehicles, and large delivery vehicles which require higher clearance. The personnel parking spaces to the south have a more favorable orientation; however, available canopy space is very limited due to the trees and the surrounding building. The Main Reserve Center is a single story facility with a higher ceiling for the Drill Room/Gym. Contractor access shall be coordinated with the base.

4.2. Site Access and Layout

The site is very compact with limited parking and buildings closely spaced. Buildings are in clusters separated by parking, or paved areas. The only "green" space on site is located south of the site facing West Foster Avenue. The A/E team entered the secured gate for personnel located off the service road just west of West Foster Avenue. There is a separate gate north of the main entrance for large truck deliveries. The northern gate appears to be the best option for contractor access. See Site Aerial Photo below.

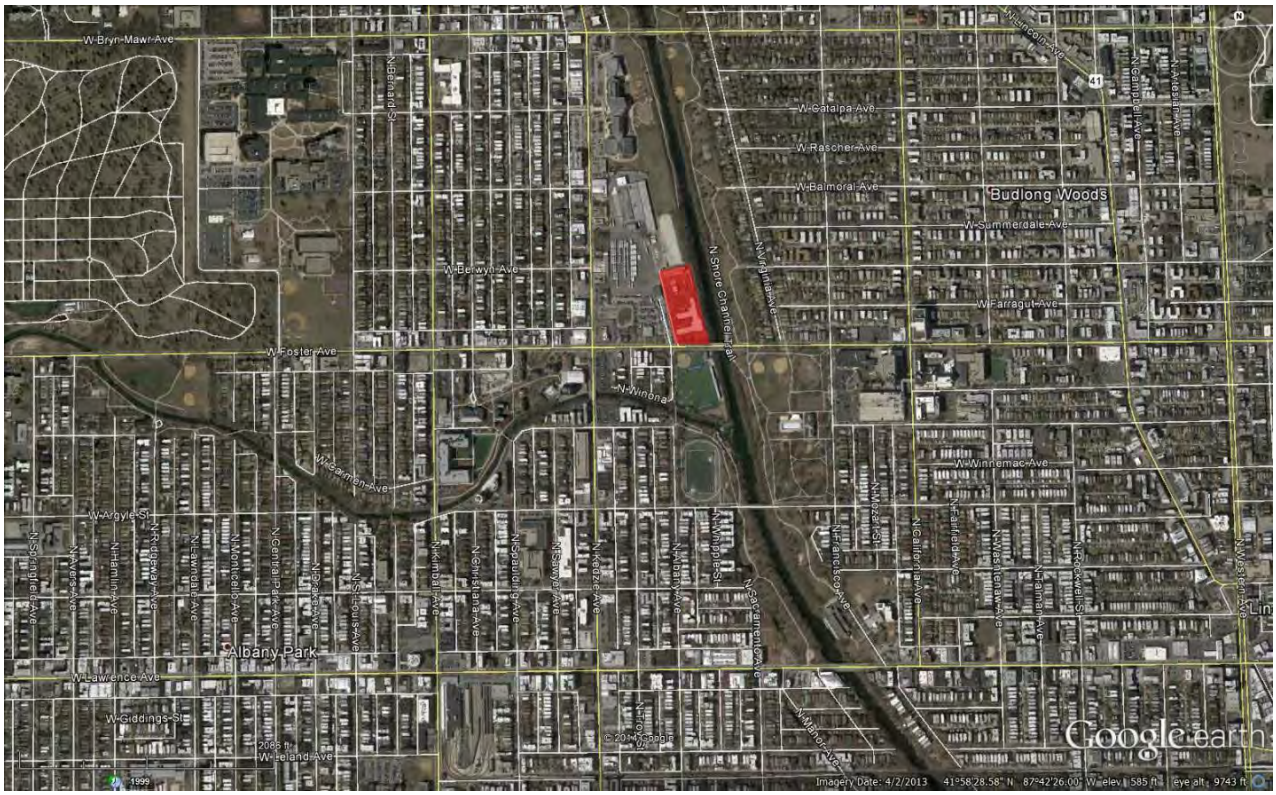

Figure 1 - Site Location

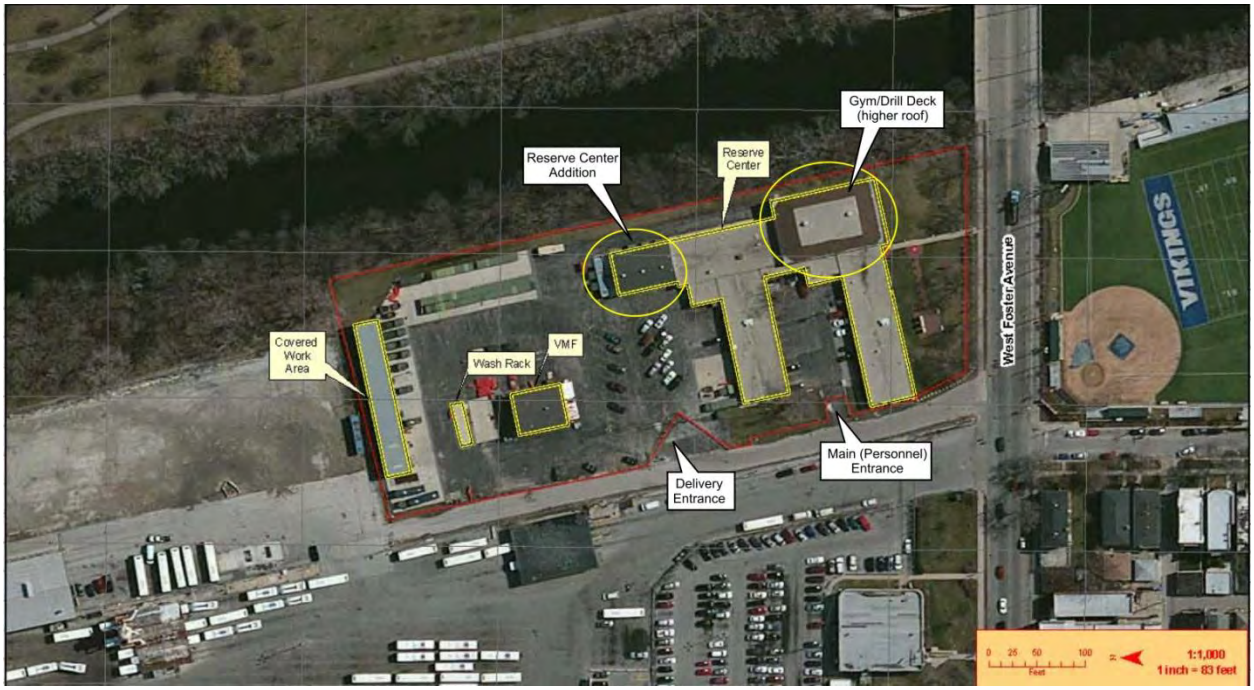

Figure 2 - Labeled Aerial Map

4.3. Site Constraints

There is a river running along the east of the site. To the west is a mass transit (bus) station. The north boundary is dedicated to military vehicle maintenance and storage. The A/E team observed a semi-truck enter the base at the delivery entrance and drive to the northern parking lot for a delivery. It is the opinion of the design team that placing covered parking in the northern parking lot would not be a viable option.

The front of the Main Reserve Center faces south towards West Foster Avenue. It is ideal to install fixed photovoltaic panels facing south in open locations that are not obstructed from trees or buildings on the east or west.

5. ARCHITECTURAL OBSERVATIONS

5.1. General Observations

The personnel gate is not visible from West Foster Ave, and the delivery gate is further north. Placing photovoltaic panels on the roof tops is the best option for this site. The parking lots are used by large vehicles, which would prohibit installing covered parking to use for the panels.

5.2. Roof Observations (Architectural)

The Main Reserve Center building has a low sloped flat roof made of 90% modified bitumen roofing material that has been repaired (covered) with a liquid applied membrane, with gravel on top for membrane protection. The building has roof access via ladders attached to the exterior walls. The flat roof slopes towards the center and rain water escapes via roof drains. The low

sloped flat roofs do not appear to be in good condition. The A/E team found evidence of roof ponding and the roof membrane appears to be swelling, perhaps due to moisture with the roofing system. At the time of the site visit, the A/E team did discover what appeared to be a leak, in the roof above the Gym/Drill Deck. The A/E team is concerned about adding a long term photovoltaic system to a roof that appears to be at the end of its lifecycle and recommends replacing the roof as its location is best suited for the PV panels.

The two (2) secondary buildings (The Main Reserve Center Addition and the Vehicle Maintenance Facility) have pitched standing seam metal roofs, however their orientation precludes them from being prime candidates for PV panel installation.

Figure 3 - Roof Photos (roof ponding and/or leaks)

It appears that the Main Reserve Center building has two (2) structural systems. The Gym/Drill Deck's structural system is conventional steel trusses supported by steel columns. and is supported by five (5) bays of steel "Pratt" trusses approximately 22'-0" on center that are attached to steel columns. The roof framing system has bar joist infill approximately 6'-0" on center.

The remainder of the Main Reserve Center has a concrete frame with a low sloped flat roof. The roof slopes down from the exterior walls towards the center. See photos below.

Figure 4 – Gym Structure, Typical Structure, Roof Slope

5.3. Limited Floor Plan Observation

The Main Reserve Center appears to have been built during the time when asbestos and lead paint were in use. There is a glue spline system above the acostical ceiling tile which is likely made with asbestos. Due to budgetary and health reasons, the A/E team will work towards solutions that do not involve contact with the space above the ceiling.

6. ELECTRICAL OBSERVATIONS

6.1. General Observations

The Main Reserve Center has an existing 800A, 3-phase, 208Y/120V service. The existing electrical gear is older and obsolete. The equipment is located in the Electrical/Mechanical room with exterior entrance doors located on the West side of the building.

6.2. Roof Observations (Electrical)

The roof where PV panels will be located on the main reserve center are flat and have some obstructions such as mechanical packaged units, vent stacks, and exhaust fans, but will not impact the PV module placement. The Main Reserve Center does not have lightning protection installed and this will need to be installed to protect the PV panels.

6.3. Electrical Room

The Main Reserve Center has an electrical/mechanical room located on the west side of building with exterior doors.

Figure 5 – Main Electrical Gear

6.4. Limitations

The buildings on site did not have roof access. All visual roof observations were completed on the ground or with a ladder provided by the A/E team.

7. STRUCTURAL OBSERVATIONS

Structural information will be forthcoming and under delivered under separate cover.

8. CHALLENGES

8.1. Architectural Challenges

None.

8.2. Electrical Challenges

The installations of PV systems for these buildings will be fairly straight forward electrically but some challenges may come as the connection into the older style main.

9. RECOMMENDATIONS

9.1. General Recommendations

The A/E team recommends placing PV panels on the existing roof structure of the Main Reserve Center.

The majority of the roof area planned for photovoltaic panels are “flat,” low sloped roofs. The Gym/Drill Deck is at a higher elevation than the rest and there are evidence of a roof leaks. The A/E Team recommends roof replacement before installing PV panels.

The roofs of the other supporting facilities (VMF, storage and vehical cover) are not oriented for the most effective use of photovoltaic panels.

PV panels shall be placed around obstacles such as plumbing vents, and mechical equipment.

Figure 6 – Layout with Buildings

Although beyond the project's Scope, the A/E suggest Fall Protection during maintenance of the photovoltaic system. For low sloped "flat" roofs, A/E suggest a non-penetrating Freestanding Anchor Tie-Off system. If standing seam metal roofs are ever installed on the Drill Hall, A/E suggest a non-penetrating Clamped Anchor Tie-Off system. The Government should consider the systems below or similar systems that would not require penetrating the roofing membrane/material and causing a potential leak.

FREESTANDING COUNTERWEIGHT ANCHOR

Freestanding Anchor Does Not Require Attachment to Working Surface and Provides a Safe and Versatile Fall Arrest Rated Tie-Off Point!

- Non-penetrating design does not attach to the working surface, reducing the possibility of damage
- Built-in shock absorbing post provides added safety to user and structure
- Fall arrest and restraint rated for one worker for jobsite versatility
- For use in general concrete, steel or asphalt construction
- Approved for use on these roof types: concrete, single ply membrane, bitumen membrane, asphalt sanded and asphalt stone chippings
- Ideal for use on flat surfaces up to a maximum of 5 degrees slope/pitch
- Counterweights are 45 lbs. (20.3kg) and come with a integral carrying handle for easy transport and set-up

FREESTANDING COUNTERWEIGHT ANCHOR

Safe and Secure Anchor The freestanding counterweight anchor provides a tie-off point for personnel performing work on flat roofs or structures. The anchor is fall arrest rated and can be used as a single anchor point system. After set-up, simply attach your shock absorbing lanyard, self retracting lifeline or rope grab and lifeline and you are ready to go.

Non-Penetrating Design This anchor is a counterweight type, simply placed on top of the working surface. Weighted bases are added to rubber trays that are connected to a shock absorbing tie-off post. The anchor's freestanding design installs without penetrating the roof sheathing or surface, saving valuable time and money. In addition, the design reduces the possibility of surface damage, roof leaks and voided roof warranties.

Specialized Load Distributing Design This anchor incorporates a revolutionary shock absorbing system called LEAP™. The LEAP™ post (with tie-off point) has an integral energy absorber that deploys in a controlled manner to absorb the forces generated during a fall. This specialized design provides added safety to the attached worker and better distributes the forces to the anchor and structure. By limiting the forces this way, the integrity of the roof is also preserved.

Easy Installation Installation of the anchor system is simple, fast and efficient. Due to its modular design, the installer will never have to lift more than 45 lbs. (20.3kg). In some applications, the entire system can be lifted (by forklift or crane) into place for instant set-up and use. Refer to instruction manual for complete details.

Counterweight Anchor Models:

7255000: Freestanding Counterweight Anchor, includes sixteen 45 lb. (20.3kg) plates, roof post, base and D-ring

7200439: Single Counterweight Only, 45 lbs. (20.3kg)

Step 1

Align rubber trays into square pattern using notches

Step 2

Install the "L" bolts into the slots on the rubber trays

Step 3

Stack plates (weights) over bolts and onto rubber trays

Step 4

Set post and base onto the "L" bolts and plates

Step 5

Install the remaining four plates and tighten bolts/nuts

Specifications:

Counterweight Plates: Cast iron, galvanized ***Rubber Trays:*** Carbon steel, PVC coating ***"L" Bolts:*** Carbon steel, galvanized
Roof Post and Base: Post is painted stainless steel, the base is painted carbon steel ***D-ring:*** Forged steel, zinc plated
Standards: Meets EN 795:1997 Class E requirements.

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New!

MILLER Fusion™

Roof Anchor Post

Permanent or Temporary Solution for Roof Safety

- Versatile single-point anchor adapts to a wide range of roof designs
- Attachment to the roof surface is quick and easy reducing installation time by more than 50%
- Protects the worker by maintaining a secure connection to the structure in the event of a fall
- Protects the structure during a fall with a unique energy-absorbing load distribution system

INNOVATIVE ENERGY-ABSORBING DESIGN

MILLER® by SPERIAN

New!

MILLER Fusion™ Roof Anchor Post

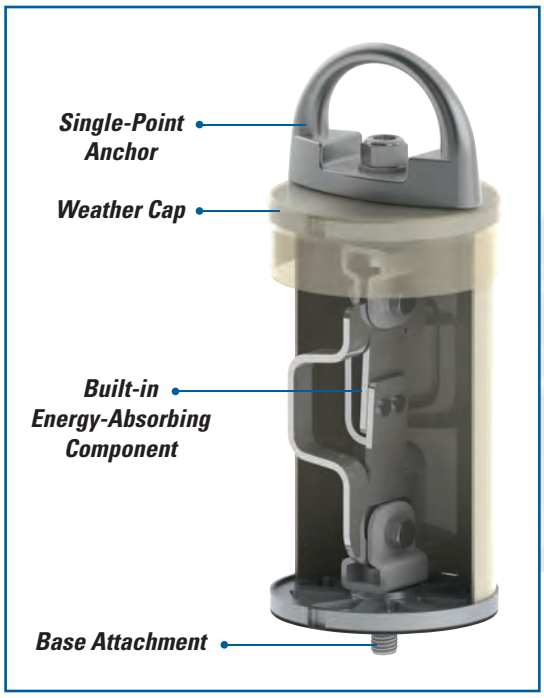
*The new versatile, single-point **Miller Fusion Roof Anchor Post** adapts to a wide range of roof designs with its innovative base plate engineered for temporary or permanent installation to the roof surface.*

When properly installed, a dependable fall protection connection is established. Should a fall occur, forces are reduced with its energy-absorbing design to maintain a secure connection to the structure.

*The easy-to-install **Miller Fusion Roof Anchor Post** is designed for quick set-up and does not require roof penetration to sub-surface rafters or trusses.*

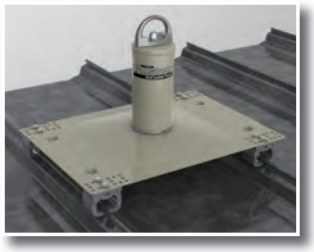
- **Versatile single-point anchor adapts to a variety of roof designs** – With a variety of models available, the Miller Fusion Roof Anchor Post can accommodate most industrial roof designs including standing seam, membrane, built-up, metal sheathing, concrete and wood.
- **Attaches to the surface of existing roof structures** – Quick, easy installation reduces cost requiring minimal labor and eliminating the need for roof penetration and repair.
- **Significantly reduces the fall forces on the roof structure** – In the event of a fall, the top of the Miller Fusion Roof Anchor Post reorients with the force in a direct line and activates the patent-pending energy absorber.
- **Durable design that withstands the changing outdoor environment** – Internal components are constructed of stainless steel. The steel post and base are plated with zinc followed by a premium powder coating for two layers of protection.
- Models for steel decking, concrete and wood can be used on other non-roof structures.

Modular bar extenders accommodate additional standing seam widths.



In the event of a fall, the Miller Fusion Roof Anchor Post orients in the direction of the force, the built-in, energy-absorbing component activates and the base remains securely attached to the roof surface.

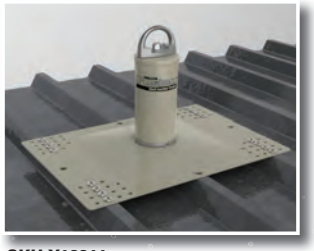
Miller Fusion Roof Anchor Post adapts to a variety of roof structures



SKU X10001

Standing Seam Design

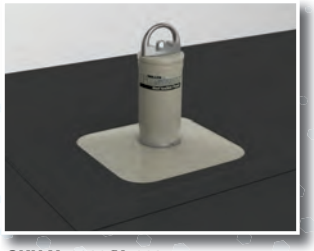
- Aluminum clamping mechanism is designed to pre-install to the base plate and is self centering for easy installation.
- The clamping bolts are tightened from above the plate for easy fastening and inspection.
- Can be used for permanent and temporary installations.
- Three models are available to accommodate standing seam spacing up to 24-inches *(610 mm)*.*



SKU X10011

Metal Sheathing Design

- Designed to attach to metal sheathing with a minimum 24 gauge *(0.024-inch [.61 mm])* thickness.
- Hardware kit includes sealing materials to prevent water damage to roof.



SKU X10030/X10031

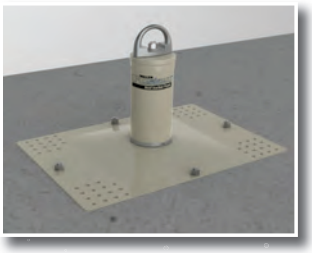
Membrane/Built-up Design

- Easy-to-install toggle kit fastens through membrane, insulation and into metal sheathing, wood sheathing or concrete.
- Models available for built-up roof thicknesses accommodate up to 10.5 inches *(267 mm)*.

SKU X10040

Wood Design

- Includes lag screw kit.
- Installs into plywood with minimum thickness of 5/8-inch *(15.9 mm)* CDX.
- *Designed for temporary installation only.*



SKU X10050

Concrete Decking Design

- Includes concrete expansion anchor kit.
- Installs into concrete decking with minimum thickness of 6.5 inches *(165 mm)* and minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*.

SKU X10020

Multi-Purpose Metal Sheathing, Wood and Concrete Design

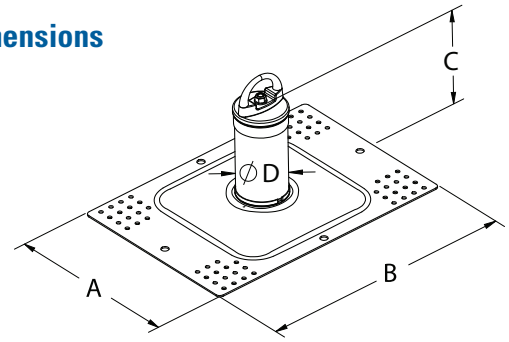
- This multi-purpose post uses the same base as models X10011, X10040 and X10050.
- Miller specified hardware must be purchased for this base. *(This model does not include hardware.)*

Applications

- *Roof inspection and maintenance*
- *Air conditioning, ventilation fan and solar panel maintenance*
- *Skylight cleaning*
- *Debris removal from gutters*
- *Installation and maintenance of satellite dishes and other communication systems*

**Complete list of models (SKUs) on back page.*

Dimensions



SKU	WIDTH A	LENGTH B	HEIGHT C	POST DIA. D
X10000 X10010	15.25 in. *(387 mm)*	18.0 in. *(457 mm)*	8.6 in. *(218 mm)*	4.0 in. *(102 mm)*
X10001 X10011 X10020 X10040 X10050		22.0 in. *(559 mm)*		
X10030 X10031			9.0 in. *(229 mm)*	
X10002	15.6 in. *(396 mm)*	26.0 in. *(660 mm)*	9.56 in. *(243 mm)*	

Specifications

Roof Anchor Post Materials

Energy Absorber:	Stainless Steel
Internal Connecting Components:	Stainless Steel
Top and Bottom Post Plates:	Anodized Cast Aluminum
Standing Seam/Wood/Metal Base Plate:	Two-layer Zinc/Powder-Coated Steel
Post Tube:	Zinc/Powder-Coated Steel
Post/Base Plate Seal:	HDPE
Post Cap:	Vinyl w/UV Inhibitor

Connection Components Materials

Standing Seam Clamps:	Anodized Aluminum/Stainless Steel
Extender Bar for Standing Seams:	Anodized Aluminum/Stainless Steel
Hardware for Metal Sheathing:	Hot Dip Galvanized/Neoprene
Hardware for Membrane:	Zinc-Plated Steel/PVC/Neoprene
Hardware for Wood:	Zinc-Plated Steel
Hardware for Concrete:	Stainless Steel

Performance

Activation Force:	1000 lbs. *(4.4 kN)*
Maximum Capacity:	310 lbs. *(140.6 kg)*

Fusion Roof Anchor Post

SKU	Description	Designed to Accommodate
STANDING SEAM ROOFING – Includes post with base and standing seam clamping assembly kit		
X10000	Small base	Standing seam spacing from 11.75 in. *(298 mm)* to 17 in. *(432 mm)*
X10001	Large base	Standing seam spacing from 11.75 in. *(298 mm)* to 21.25 in. *(540 mm)*
X10002	Large base & extension bars	Standing seam spacing from 11.75 in. *(298 mm)* to 24 in. *(610 mm)*
METAL SHEATHING ROOFING – Includes post with base and rivet kit with sealing washers and mastic tape		
X10010	Small base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])*
X10011	Large base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm]).* Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments.
MEMBRANE/BUILT-UP ROOFING – Includes post with base and toggle bolt kit		
X10030	Up to 5.5 in. *(140 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of up to 5.5 in. *(140 mm)*
X10031	> 5.5 in. *(140 mm)* & up to 10.5 in. *(267 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of > 5.5 in. *(140 mm)* up to 10.5 in. *(267 mm)*
WOOD SHEATHING (TEMPORARY INSTALLATIONS ONLY) – Includes post with base and lag screw kit		
X10040	Wood sheathing	Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX
CONCRETE ROOFING – Includes post with base and concrete expansion bolt anchor kit		
X10050	Concrete	Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*
MULTI-PURPOSE METAL SHEATHING, WOOD AND CONCRETE ROOFING (NO HARDWARE INCLUDED) – Includes post with base. Hardware selection is based on the application. See instruction manual for hardware specifications.		
X10020	Metal sheathing, wood or concrete	• Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])* • Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments. • Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX • Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*

Meets or exceeds all applicable industry standards including OSHA, ANSI A10.32 and Z359.1-2007.

This equipment should only be used after reading the manufacturer's instructions. Failure to follow instructions could result in serious injury or fatality.

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LMFRP/0810/30M/RPI

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Appendix – B Annotated Design Review Comments

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Public / SBU / FOUO

Comment Report: All Comments
Project: MARFORRES PV Systems Design
Review: Chicago Design Analysis 35% Submittal
Displaying 11 comments for the criteria specified in this report.

Id	Discipline	DocType	Spec	Sheet	Detail
5692514	Facilities Maintenance	Specifications	n/a	I-1 VII-1	n/a

Comment Classification: **Public (Public)**
Coordinating Discipline(s): Facilities Maintenance

Several mentions for the roof at Chicago needs replacement. This was recently accomplished on 10 June 2014. The new roof material is PVC with cushioned walk pads in high traffic areas.

Submitted By: James Webb (816-843-3746). Submitted On: Jun 23 2014

1-0 Evaluation **Concurred**
Thank you for the information

Submitted By: Francis Oakes (678-281-0907) Submitted On: Jul 29 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: James Webb (816-843-3746) Submitted On: Aug 13 2014

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: James Webb (816-843-3746) Submitted On: Aug 13 2014
Current Comment Status: **Comment Closed**

5692520	Facilities Maintenance	Specifications	n/a	Installation Guide	n/a

Comment Classification: **Public (Public)**
Coordinating Discipline(s): Facilities Maintenance

After reviewing the installation guide, anchors and roof penetrations, sealing these penetrations and roof warranty avoidance come to mind.

Submitted By: James Webb (816-843-3746). Submitted On: Jun 23 2014

1-0 Evaluation **For Information Only**
The flat portion of the roof will not be required to be fastened throught the roof membrane. The only portion that will require penetration is the south facing sloped roof.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Jul 29 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: James Webb (816-843-3746) Submitted On: Aug 13 2014

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: James Webb (816-843-3746) Submitted On: Aug 13 2014
Current Comment Status: **Comment Closed**

5692582	Facilities Maintenance	Specifications	Danger, Warnings, Caution, Notice, Junction Box Labeling	Installation Manual	Important Safety Information

Comment Classification: **Public (Public)**
Coordinating Discipline(s): Facilities Maintenance

These notices need to be posted at the junction box, distribution panel,roof access, on the equipment and at the Microinverters.

Submitted By: James Webb (816-843-3746). Submitted On: Jun 23 2014

1-0 Evaluation **Concurred**
We can add a note to include these signs at the locations specified above.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Jun 30 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: James Webb (816-843-3746) Submitted On: Aug 13 2014

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: James Webb (816-843-3746) Submitted On: Aug 13 2014
Current Comment Status: **Comment Closed**

5762616	Electrical	Plans	n/a	n/a	PV Panel – Conductors

Comment Classification: **For Official Use Only (FOUO)**

Please provide details in Plans and DA that indicate how the conductors are to be secured, both along the rooftop and down to their controller(s).

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

The fastening of conductors and conduits fall under means and methods of the eletrical contractor and the contractor shall use the most appropriate means to do so.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762617	Electrical	Plans	n/a	n/a	Utility Disconnect

Comment Classification: **For Official Use Only (FOUO)**

Although the Enphase Micro-Inverter serves as an AC disconnect, you still need to verify with AHJ if a separate, Utility disconnect is required, esp for Fire Dept. Need to verify if this is not required by IEEE. It is covered in 2014 NEC, Article 690.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

A fused disconect is shown on the one line for the utility company. The utility company may chose to padlock the disconnect on so we feel it is better to have another means that is also in control of the facility.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762618	Electrical	Plans	n/a	n/a	Surge Suppression

Comment Classification: **For Official Use Only (FOUO)**

Please include catalog data for surge protection equipment proposed. Consider including a key note in plans that references catalog data, or include particulars on sheet.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**
The SDP is staed on sheet e-602. I have varified that the SPD has an EGC.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014
Backcheck not conducted
Current Comment Status: **Comment Open**

5762621	Electrical	Plans	n/a	n/a	Vdrop – jBox Loc

Comment Classification: **For Official Use Only (FOUO)**

Why are there no details to show locations of jBoxes? Are they always at the 1st PV Panel in the array? Some calcs show a distance from the last PV Panel to the jBox. Is that the longest run of conductors in that circuit?

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**
J boxes are shown on the typical detail but would not fit or be legible on the plan view. This falls under means and methods of the contractor. However the voltage drops give the length to where I feel they should be located. The inverter will have to placed next to the module it feeds in additon with the temperature correction factor as well as using less than the 24 max modules this will offer some flexability to the contractor.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014
Backcheck not conducted
Current Comment Status: **Comment Open**

5762622	Electrical	Plans	n/a	n/a	PV Array – Load

Comment Classification: **For Official Use Only (FOUO)**

Revisit Panel schedules to verify loads(VA) per array (15ea panels max). Some circuits are showing a load of only 1200VA for a 15-panel array. This seems low, unless the power value I'm using, 264Wac(275Wx0.96,)is too high.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**
The inverters have a continuous max rating of 240W as stated on the datasheets, this is what the panel will see. We are using less than the max 24 modules since the VD drop calcs porvided from the manufacturer did not consider temeprature derating in their calc.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014
Backcheck not conducted
Current Comment Status: **Comment Open**

5762623	Electrical	Plans	n/a	n/a	PV Array – 1ph vS 3ph

Comment Classification: **For Official Use Only (FOUO)**

It appears, by your labeling convention, that the PV Panels are connected using 2-poles (1phase). However, the Sub-Panels show the PV Panel circuits as 3ph? Is this 1phs-3phs transition occurring at the jBox?

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

The inverters are single phase 208V but are connected and wired in a way that they are three phase 208V as seen by the eletrical panel.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762624	Electrical	Design Analysis	n/a	n/a	Surge Suppression

Comment Classification: **For Official Use Only (FOUO)**

Please update DA to reflect what is being used to meet lightning protection of solar PV equipment. Many designs simply show surge suppression.

Submitted By: Gerald Choate (817-886-1969). Submitted On: Aug 13 2014

1-0 Evaluation **For Information Only**

Lightning protection is not currently in our scope of work for the PV systems, however buildings that have existing lightning protection system will be provided with a note to extend the LPS in accordance with NFPA 780-2014 considering PV systems were not iin the previous standard 780. Building without LPS no action will be taekn since the existing buildings had not required LPS, however the solar panels are grounded and an SPD at the panel is provided.

Submitted By: Francis Oakes (678-281-0907) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

5762672	Architectural	Cost Estimate	n/a	n/a	n/a

Comment Classification: **Public (Public)**

Panels on teh SE Bldg are shown extending of the ridge cap.
Also, Please confirm the number of modules on the Drawing adds up to the proposed KW.

Alternate Covered Parking locations to replace the roof mounted modules shown on the Site Plan may be required.

Please contact Justin Runnels 225.573.5024 for more information.

Submitted By: Justin Runnels (2255735024). Submitted On: Aug 13 2014

1-0 Evaluation **Concurred**

The modules have been relocated and the proposed KW are provided in the 100% documents.

Submitted By: Bernard Braddick (405-340-9503) Submitted On: Aug 18 2014

Backcheck not conducted

Current Comment Status: **Comment Open**

Public / SBU / FOUO
Patent 11/892,984 ProjNet property of ERDC since 2004.

Appendix – C Structural Calculations and Cut Sheets

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CALCULATIONS - CHICAGO

PV system loading to the existing framing system will be evaluated using a methodology that reflects roof-top equipment on existing roofs. This means that 20 psf live load that was included in the original building design will be superceded by 4 psf equipment load plus wind or seismic

Wind forces to the main wind force resisting system (MWFRS) are computed based upon IBC 2012 criteria using allowable stress design.

Basic load combinations per IBC 2012, SECTION 1605.3 include:

D + F

D + H + F + L

D + H + F + (Lr OR S OR R)

D + H + F + 0.75(L) +0.75(Lr OR S OR R)

D + H + F + (0.6W OR 0.7E)

D + H + F + 0.75(0.6W)+ 0.75(L) + 0.75(Lr or S or R)

D + H+ F + 0.75(0.7E) +0.75L + 0.75S

0.6D + 0.6W + H

0.6 (D + F) +0.7E +H

The above excludes exceptions per 1605.3.1

Main Reserve Center

New solar panel array per arch. layout

Added loads to the existing building from solar panels:

D = 4 psf (sunmodule + Renusol mounting rails)

W = 26.994 psf (Y-Y); 22.301psf (X-X) (MWFRS) see wind analysis

R = 0 (rain)

H = 0

F = O

L = 0

Lr = 20 PSF BETWEEN SOLAR PANEL ARRAY BUT Lr=0 WHERE SOLAR PANELS

S = 20 psf (roof snow)

Consider worse case -Y-Y: D + 0.6W = $4+(.6\cdot(26.994))=20.2$ psf

(This is the verticalwind pressure normal to the ridge)

Consider worse case X-X: D + 0.6W = $4+(0.6\cdot 22.301)=17.38$ psf

(This is the horizontal component ofwind pressure normal to ridge)

The existing roof framing except for the gym / drill hall is framed of deck spans averaging 13.33 ft. Concrete beams support interior reactions of the roof slab and cmu/brick supports the perimeter. This roof framing system is vintage, perhaps 1950's and the most expedient approach to verifying the integrity of the roof for new solar panel loads is to reason that without live loads the overall impact of 4 psf panel load leaves equivalency of 16 psf from either added wind pressure or added seismic.

The drill hall roof is sloped, approximately 3V:12H and framed of structural steel and bar joist rafters. The lateral wind pressure added to the existing roof will require increasing the stiffness of the column / beam connections at the five column frames.

Consider lateral loads from PV system on existing steel rigid frames and design stiffener at haunch to effectively bring the building stiffness to original design:

PV panel = sunmodule panel 39.41 x 65.94 x 1.22

$$F\ (wh) = \left(22 \cdot \left(3 \cdot \frac{65.94}{12}\right) \cdot 22.301 \cdot .33\right) = 2669.01 \quad \text{lbs}$$

$$F\ (wv) = \left(22 \cdot \left(3 \cdot \frac{65.94}{12}\right) \cdot 26.994\right) \cdot \frac{3}{12} = 2447.48 \quad \text{lbs}$$

$$Mx\ (haunch) = \left(2.67 + 2.47\right) \cdot \frac{18}{2} = 46.26 \quad \text{k-ft}$$

$$\text{Use side plates at haunch with a } Sx(req'd) = \frac{\left(46.26 \cdot 12\right)}{32} = 17.35 \text{ in}^3$$

$$\text{try (2) 1/4" plates, h=15", } Sx = 2 \cdot \frac{\left(0.25 \cdot 15^{\,2}\right)}{6} = 18.75 \text{ in}^3 \quad \text{Say O.K.}$$

Consider Renusol Rail Section properties about centroid:

This is aluminum 6063-T6 grade with an allowable Fb=14.32 ksi with an unbraced length of the compression side = 6 ft.

Sx = 0.33148 in.^3 r(x) = 0.83364 in.
Sy = 0.19985 in.^3 r(y) = 0.50589 in.
A = 0.56739 sq. in.
height = 2.361 in.

Using clip spacing directly over roof joists at 6'-0" c/c and rail spacing under solar panels of 3'-0" c/c :

Rails -

$$M(x) = \frac{\left(26.994 \cdot \frac{3}{2}\right) \cdot 6^2}{8} = 182.21 \text{ ft-lbs}$$

$$f\,(bx) = \frac{182.21 \cdot 12}{0.33148} = 6596.24 \text{ psi} < 14{,}320 \text{ psi, say o.k.}$$

$$M\,(y) = \frac{22.301 \cdot \frac{3}{2} \cdot 6^2}{8} = 150.53 \text{ ft-lbs}$$

$$f\,(by) = \frac{150.53 \cdot 12}{0.19985} = 9038.58 \text{ psi} < 14{,}320 \text{ psi, say o.k.}$$

If the connection clip is positioned by the installer between existing roof purlins and not directly over purlins: Use Unistrut P5000 shape.

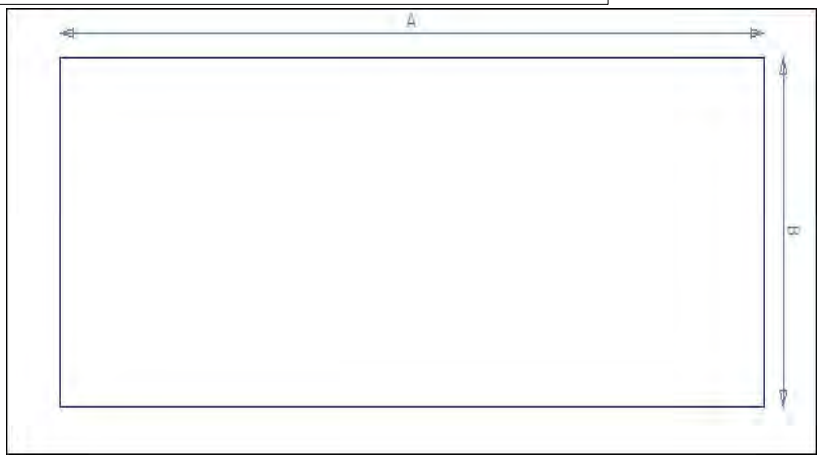
Company:	dunlap associates	**Date:**	Tue, Aug 12 14
Address:	3440 blue springs road, suite 503B		
Country:	United States		
State:	Georgia		
Zip:	30144		

Load Generator Report

Input

Building Data

Load Code	2012 IBC w/ ASCE 7-10



Building Template Dimensions:

Dimension	Value
A (ft)	126
B (ft)	50
C (ft)	N/A
D (ft)	N/A
E (ft)	N/A
F (ft)	N/A

Location:

Zip Code	60602
Address	60602 CHICAGO, IL

Geometry :

Building Width (ft)	50
Building Length (ft)	126
Ridge Height (ft)	12
Eave Height (ft)	12
Mean Height (ft)	12

Stories :

Number of Stories	1

Floor	Story Height (ft)
Roof	12

Roof :

Roof Type	Roof Angle (degrees)	Roof Slope (X/12)	Overhang	Parapet	Parapet Height (ft)
Flat	0	0.000	N/A	No	N/A

Design Parameters :

Risk Category:	II

*** Ridge direction is considered parallel to Building length, switch building dimensions if needed for proper ridge orientation.**

Wind Data

Wind Load Data :

Exposure	C
Basic Wind Speed (mph)	115
GCpi	(+0.18)(-0.18)
Kzt	1
Kd	0.85
Building Corner Distance a (ft)	4.8

Component and Cladding Wall and Roof Data :

Wall Effective Area (ft²)	275
Roof Effective Area (ft²)	100
Overhang Effective Area (ft²)	N/A
Parapet Effective Area (ft²)	N/A

Wind-Blowing Story Area:

Story	Story Area Facing X dir.(ft²)	Story Area Facing Y dir.(ft²)
Roof	600	1512

Seismic Data

Common Seismic Data :

Basic System Category	Building Frame Systems
Basic System	Ordinary plain masonry shear walls

Building height limits for Seismic Design Categories (ft) :

A,B	C	D	E	F
NL	NP	NP	NP	NP

Design Coefficients and factors :

R	Omega	Cd	CT	x	Site Class
1.5	2.5	1.25	0.02	0.75	D

Design Requirements :

Ss(%g)	S1(%g)	Fa	Fv	TL (sec)
16.207	5.928	1	Calculated	12

Loads:

Floor	Area (ft²)	Dead Ld. (psf)	Part Live Ld. (psf)	Partition Ld. (psf)	Equipment Ld. (psf)	Part Snow Ld. (psf)
Roof	6300	40	20	10	4	25

Snow Data

Ground Snow Load (psf)	25
Roof Surface Type	All Other Surfaces

Terrain Category and Roof Exposure :

Roof Exposure	Fully Exposed
Terrain Category	C

Thermal Condition	Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds 25 °F × h × ft²/Btu (4.4 K × m²/W)

Output

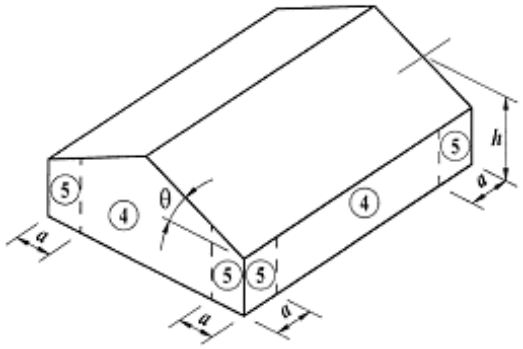
Wind Output

Component and Cladding:

Walls :

Zone 4		
GCp	**P (+GCpi) (psf)**	**P (-GCpi) (psf)**
0.6712	12	20.795
-0.7612	-22.993	-14.199

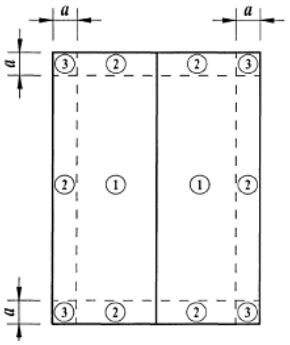
Zone5		
GCp	**P (+GCpi) (psf)**	**P (-GCpi) (psf)**
0.6712	12	20.795
-0.8025	-24.000	-15.206



Note: Illustration may not represent actual building roof type

Roofs :

Zone	GCp	P (+GCpi) (psf)	P (-GCpi) (psf)
Zone 1	-0.9	-26.383	-17.589
Zone 2	-1.1	-31.269	-22.475
Zone 3	-1.1	-31.269	-22.475



MWFRS :

Walls :

Wind Load in X Direction :

Windward Cp	0.8	Leeward Cp	-0.274	Side wall Cp	-0.7

Height (ft)	Windward P(+GCpi) (psf)	Windward P(-GCpi) (psf)	Leeward P(+GCpi) (psf)	Leeward P(-GCpi) (psf)	Side wall P(+GCpi) (psf)	Side wall P(-GCpi) (psf)
6	12.214	21.009	-10.087	-1.292	-18.932	-10.138
12	12.214	21.009	-10.087	-1.292	-18.932	-10.138

Wind Load in Y Direction :

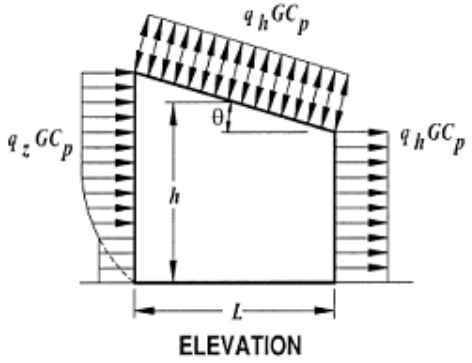
Windward Cp	0.8	Leeward Cp	-0.5	Side wall Cp	-0.7

Height (ft)	Windward P(+GCpi) (psf)	Windward P(-GCpi) (psf)	Leeward P(+GCpi) (psf)	Leeward P(-GCpi) (psf)	Side wall P(+GCpi) (psf)	Side wall P(-GCpi) (psf)
6	12.214	21.009	-14.779	-5.985	-18.932	-10.138
12	12.214	21.009	-14.779	-5.985	-18.932	-10.138

Roofs :

Parallel to ridge wind load values :

Cp	Horizontal Distance (ft)	P(+GCpi) (psf)	P(-GCpi) (psf)
-0.9	0 to h/2	-23.085	-14.291
-0.9	h/2 to h	-23.085	-14.291
-0.5	h to 2h	-14.779	-5.985
-0.3	> 2h	-10.627	-1.832



Note: Illustration may not represent actual building roof type

Normal to ridge wind load values :

Cp	Horizontal Distance (ft)	P(+GCpi) (psf)	P(-GCpi) (psf)
-0.9	0 to h/2	-23.085	-14.291
-0.9	h/2 to h	-23.085	-14.291
-0.5	h to 2h	-14.779	-5.985
-0.3	> 2h	-10.627	-1.832

Story Lateral Load :

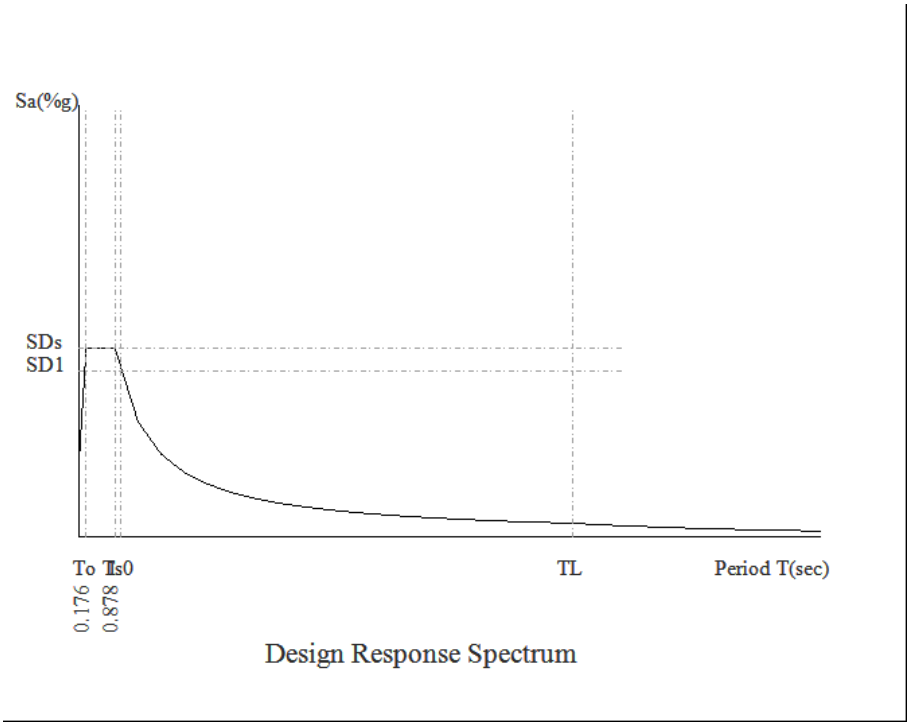
Lateral Wind Load in X Direction :

Floor	Design Pressure (psf)	Lateral Load (lbs)
Roof	22.301	6690.33
Total		6690.33

Lateral Wind Load in Y Direction :

Floor	Design Pressure (psf)	Lateral Load (lbs)
Roof	26.994	20407.37
Total		20407.37

Seismic Output



Design Response Spectrum

Design Parameters :

Importance Factor	1	**Fa**	1	**SDs**	0.108	**Cs**	0.072	**V (lbs)**	44925.8
SDC	B	**Fv**	2.4	**SD1**	0.0948	**T (sec)**	0.1289	**W (lbs)**	623700

Stories :

Floor	Base Height (ft)	Gravity Ld. (lbs)	Cvx	Floor Force (lbs)	Cumulative Shear (lbs)
Roof	12	623700	1	44925.81	44925.81

Snow Output

Roof Snow Load (psf)	20
Thermal Factor (Ct)	1.1
Roof Slope Factor (Cs)	N/A

Renusol VS

Installation Guide

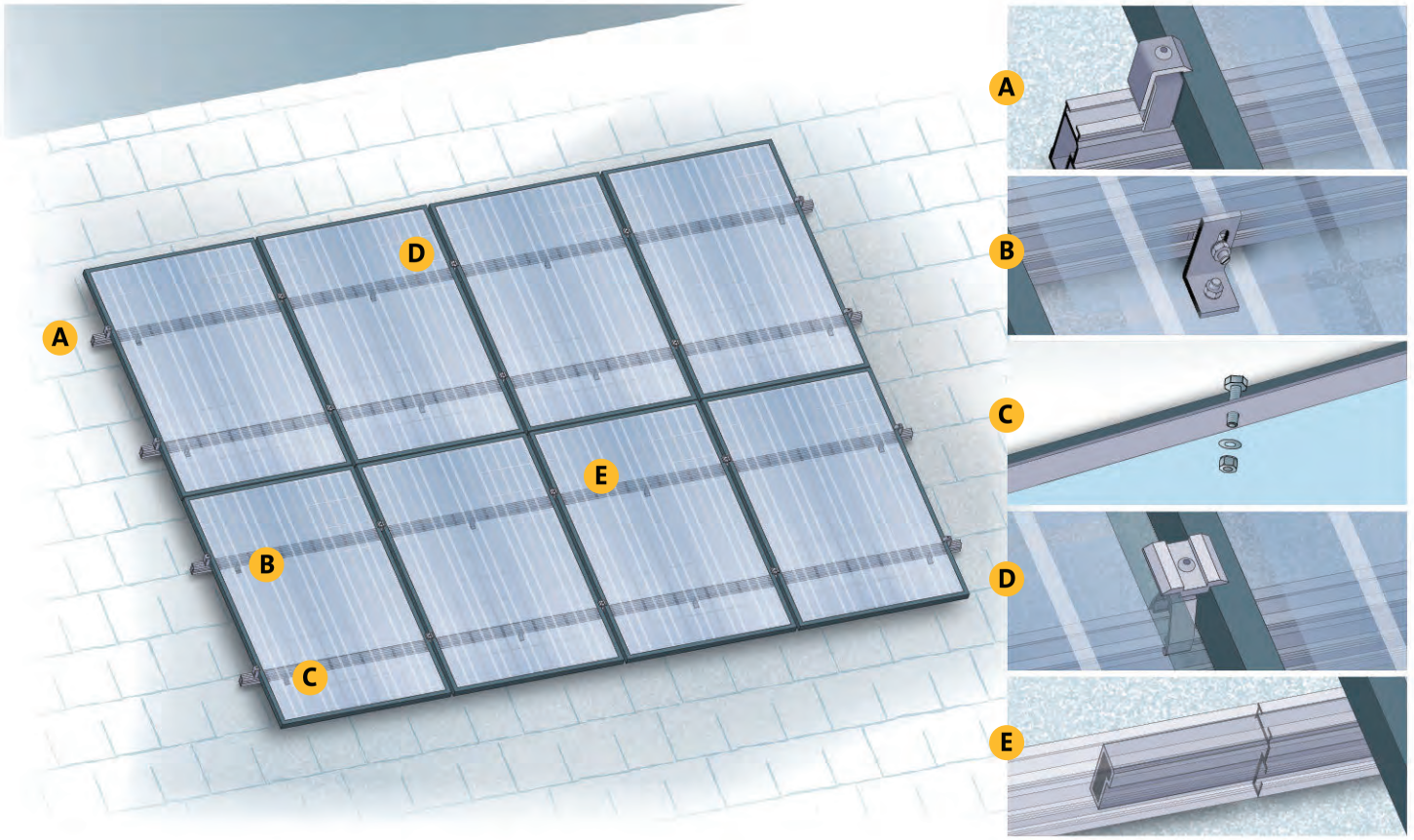
OVERVIEW

The Renusol VS racking system has been developed for easy installation of solar pv system on pitched roofs. It includes proprietary "one size fits all" clamps for all module thicknesses ranging between 31-51 mm.

Please refer to VS Design Guide for system layout and grounding instructions.

Please read this guide carefully before starting the installation. Always follow proper safety precautions. Be sure to check local building codes to ensure compliance.

Please check for the latest version of the installation guide at www.renusolamerica.com.

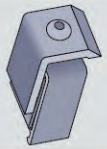


REQUIREMENTS

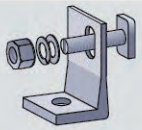
1. 5 mm Allen (hex) wrench
2. 13 mm open-end wrenches and/or sockets and rachets
3. 7/16" open ended wrenches
4. Code compliant flashing to attach L-feet to roof
5. WEEB-CCR grounding washer

SYSTEM COMPONENTS LIST

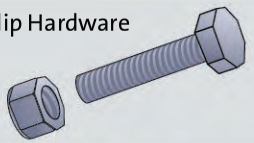
A End Clamp



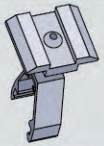
B L-Foot



C Anti-slip Hardware

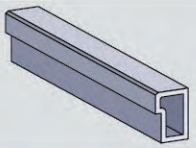


D Middle Clamp



E Renusol VS Rail

F Rail Splice Connector

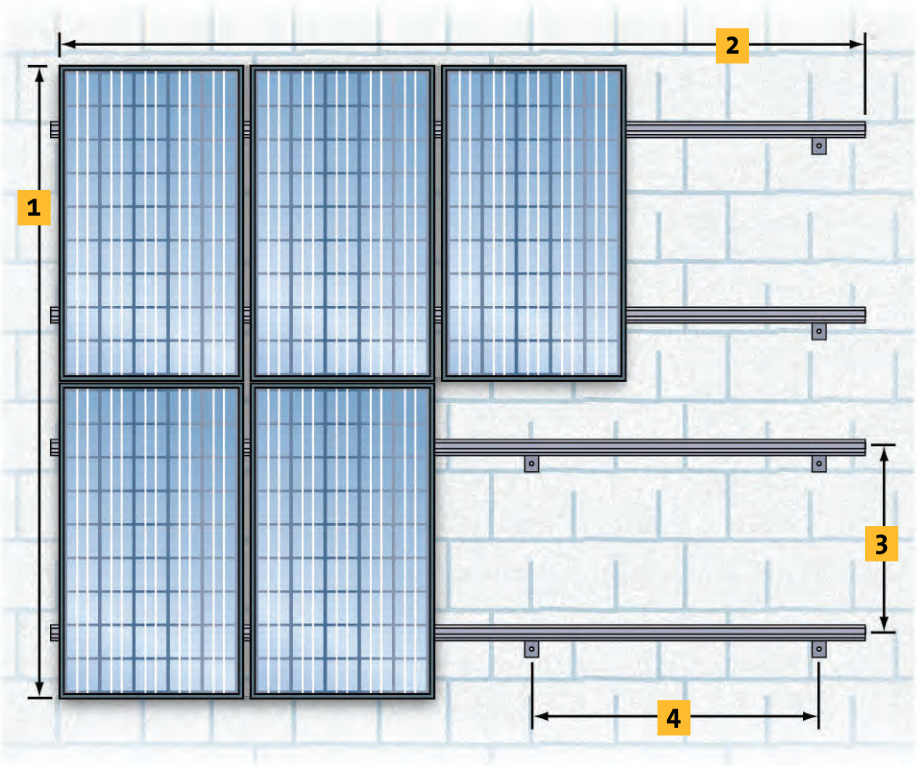


Renusol
Solar Mounting Systems

Renusol VS

Installation Guide

LAYOUT



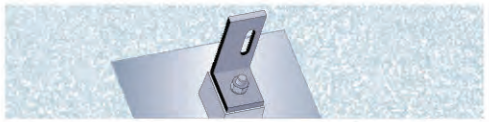
Plan the layout of the components per the dimensions below:

1. Quantity of modules in the vertical direction x (module length + 0.75")
2. Quantity of modules in the horizontal direction x (module width + 0.75") + 2.50"
3. Approximately 2/3 to 3/4 of the module length (please refer to module manufacturer's specifications)
4. For spacing of mounting brackets, please refer to the Renusol VS Design Guide. Note that one mounting bracket should be used near each splice connection.

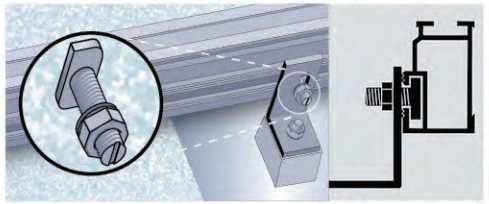
Renusol Solar Mounting Systems

Renusol America
1292 Logan Circle NW, Atlanta, GA 30318
www.renusolamerica.com
+1 877-847-8919

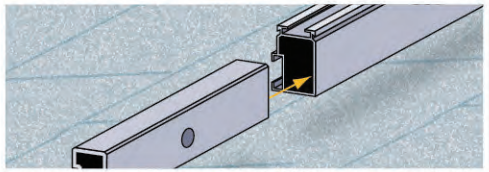
ASSEMBLY



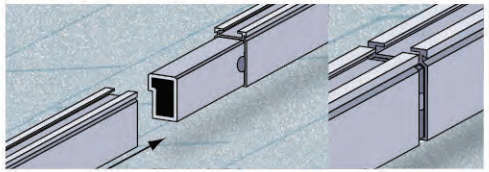
Step 1: Flashing and L-feet
Install code compliant flashing per the manufacturer's instructions and attach L-feet.



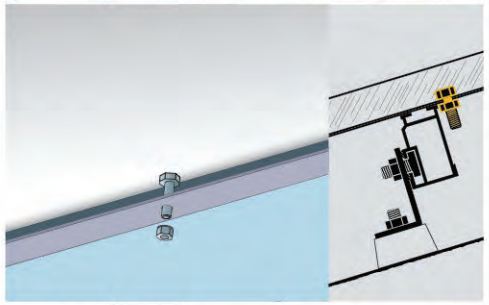
Step 2: Rails
Attach the rails to the L-feet using the T-bolts and nuts. To ensure the T-bolts are properly aligned, make sure the line on the end of the T-bolt is perpendicular to the rail. Tighten to 10 ft-lbs.



Step 3: Splice Connectors
Splice connectors are required to connect rails together. Slide a splice connector into the first rail until the head of the rivet stops the splice connector.

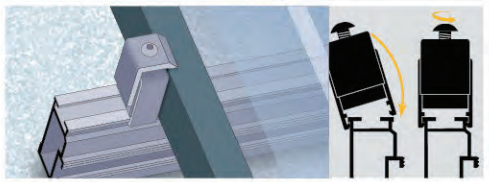


Step 4: Splice Connectors
Slide the end of the second rail over the splice connector until the rivet head stops the splice connector. There will be a slight gap between rails for thermal expansion.

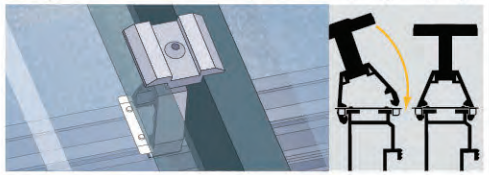


Step 5: Anti-slip Protection
Before installing the bottom row of modules, anti-slip hardware could be added for protection. To do this, attach two ¼-20 bolts and nuts through the pre-drilled holes in the module frames.

Lay the modules on the bottom row of rails so the anti-slip hardware rests against the inside edge of the bottom rail.



Step 6: End Clamps
Snap the end clamps about 1/2" from the end of the rails. Secure the modules by turning the 5mm Allen bolt, tighten to 8 ft-lbs.



Step 7: Middle Clamps
Place WEEB-CCR onto rail. Snap middle clamps over WEEB and onto rails, slide against the module. Slide next module against middle clamp, tighten to 10 ft-lbs.

Note: When using anti-sieze, the torque setting should be reduced to 5 ft-lbs for both End Clamps and Mid Clamps.

Appendix – D PV System – Shadow Analysis/Site Plan

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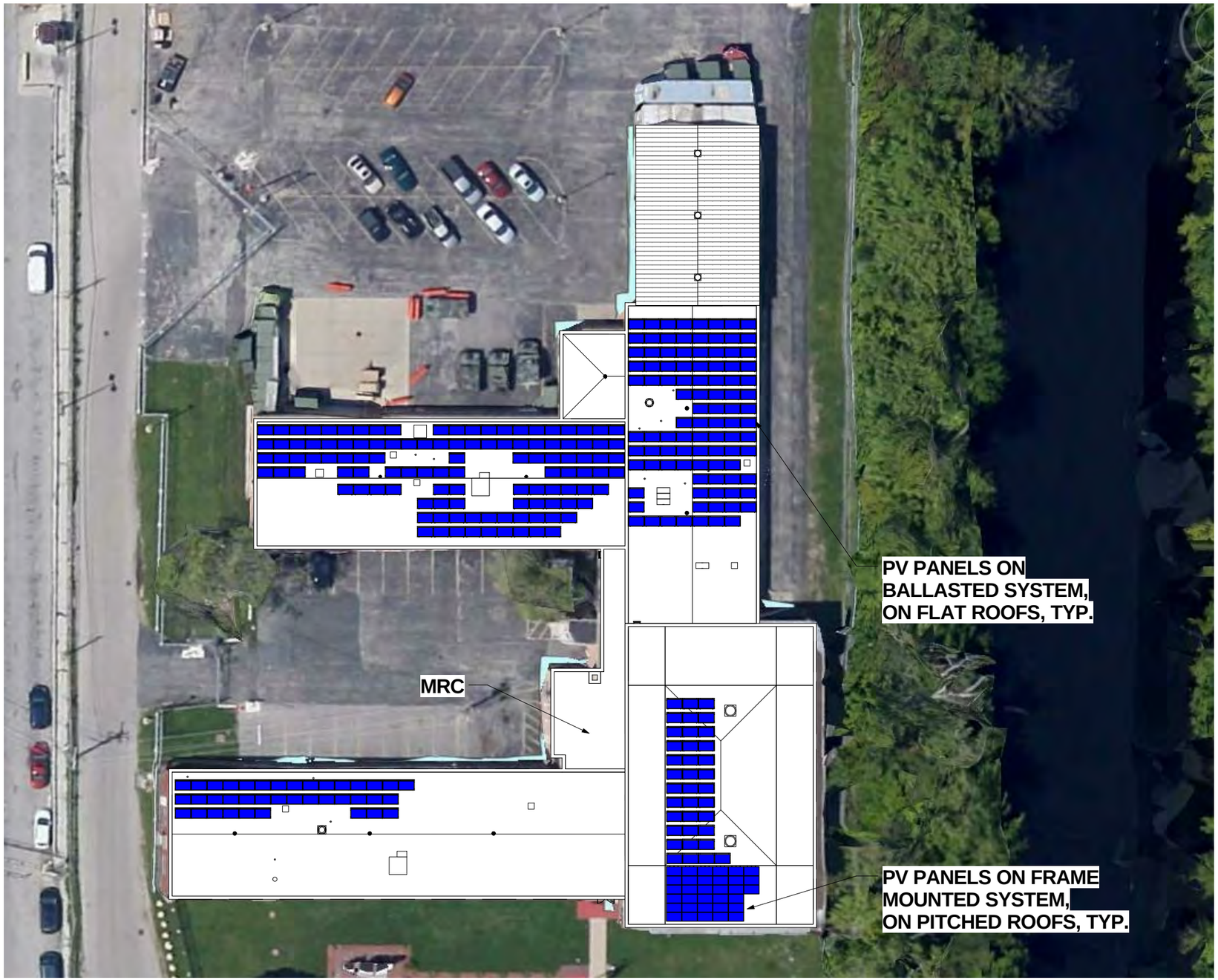

TOTAL NUMBER OF PANELS SHOWN = 320

TRUE NORTH

PLAN NORTH

1 **SHADOW ANALYSIS - SITE PLAN**

NOT TO SCALE :'

SYM	DESCRIPTION	DATE	APPR

Designed By: Bernard Braddick
Drawn By: Bernard Braddick
Checked By: Eric Morehouse
Submitted By: Rick Vicente

DEPARTMENT OF THE ARMY
US ARMY CORPS OF ENGINEERS
FORT WORTH, TEXAS

BLAIRREMY ARCHITECTS
MERRICK & COMPANY
7 MOOT WAYTE DR. 2244 N. ACE STE 230
OKLAHOMA CITY, OK 73120 PH: 405.840.9933
Aurora, Colorado 80011
Phone: (303) 751-0741

MRF CHICAGO
Chicago, IL
Solar Photovoltaic Systems

SHADOW ANALYSIS - SITE PLAN

Sheet Reference Number
A-100
Sheet of

UNREVIEWED - NOT FOR CONSTRUCTION

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US Army Corps of Engineers
Fort Worth District
819 Taylor Street
P.O. Box 17300
Fort Worth, TX 76102

Marine Corps Reserve Training Center

Chicago, Illinois

88kW Photo Voltaic Array
PV Designer Report

July 16, 2014

Prepared by

Merrick & Company
3575 Koger Blvd
Duluth, GA 30096
(404) 739-5100

Table of Contents

Table of Contents 1
Executive Summary 2
Project Site Plan 3
PV Designer Report - Summary 4
Chicago Main Building Pitch: 5
Chicago Main Building (South Side) 6
Chicago Main Building Middle 7
Chicago North Wing 8
Chicago South Wing 9
Solar Access and Shade Report – Chicago Main Building Pitch 10
Solar Access and Shade Report – Chicago Main Building (South Side) 12
Solar Access and Shade Report – Chicago Main Middle 16
Solar Access and Shade Report – Chicago North Wing 20
Solar Access and Shade Report – Chicago South Wing 24
Supporting Data for PV Design in Chicago 28

APPENDICES

Appendix A – PV Module Space Calculation Flat Roofs

Appendix B – Catalog Cut Sheets

Appendix C – Payback Calculation

Executive Summary

The Photovoltaic (PV) System to be installed at this project site is to provide a minimum 88kW output. The calculated output of the designed layout is 88kW, as shown in the PV Designer Report - Summary section of this report. The PV collection modules to provide this output will be installed on the Main building in roof areas defined in the Site Plan below. The areas of interest are the South Pitch, Main Building South, Middle Roof, South Wing, and North Wing. All flat roof systems will support a PV array with a 10º tilt, with a spacing of 24 inches minimum between modules. The site has several trees to east and south side of several roof systems. Placement of PV modules were limited to areas where excessive tree shading was impacting the roof area as well as roof mounted equipment. Panels mounted on the Main Building roof are installed flat against the existing slope of the roof. All roof system are due south with an approximate azimuth of 167º.

The PV modules selected for this installation are the SolarWorld Model Protect SW 275, connected through Enphase Energy inverters, Model M250. The derating factor for all modules installed under this project is 0.76. The system payback calculations for this project site will be calculated after the construction cost for this site is estimated.

The average monthly energy usage for the Chicago site is approximately 36,000kWH with an average cost of $0.09/kWH. The 88kW-DC rated system will produce a monthly average of 7421kWH thereby reflecting an estimated average reduction of 21% in energy demand from the local power company.

The power company serving the Chicago site is ComEd. ComEd currently does not offer PV installation incentives. Illinois Power Agency (IPA) offers electricity procurement plans for investor-owned electric utilities supplying over 100,000 Illinois customers who may be seeking Solar Renewable Energy Credits (REC). IPA plans and administered the competitive procurement process that result in bilateral agreements between the utilities and wholesale electric suppliers. IPA does not offer current rates for energy credits and therefore not considered at this time. Therefore, the estimated installation cost for the site is $5.20/kW for a total of $457.6K for installed cost. Assuming building modifications are not required for the installed system. The payback for this system is approximately 57 years.

Project Site Plan

Site Plan – Marine Corps Reserve Training Center Chicago, Illinois

PV Designer Report - Summary

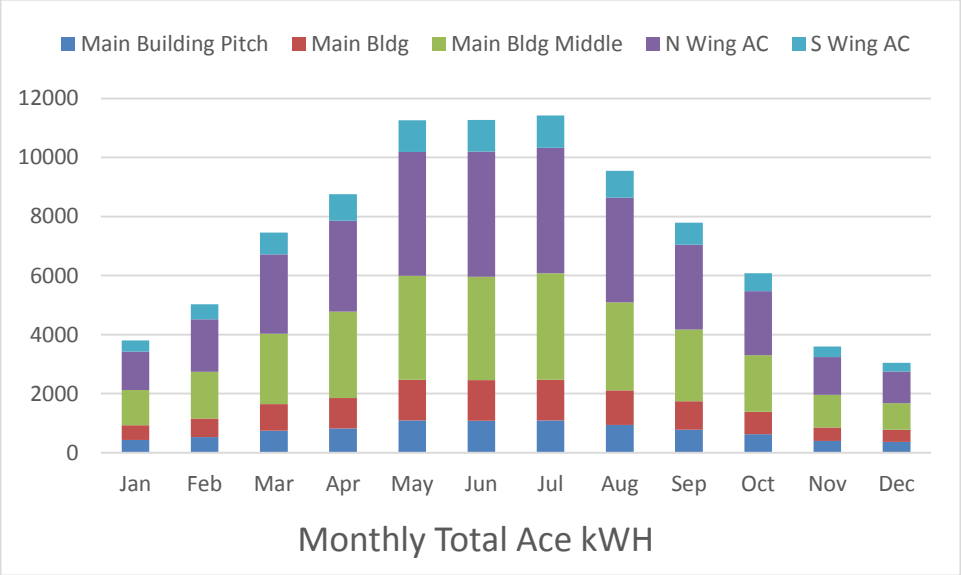
Chicago System Summary:

Location: 42.00 °N, 87.70 °W Minimum
Temperature: -27.00 °F Maximum
Temperature: 104.00 °F

Weather Properties:

Station Name: Chicago-O'Hare Intl AP
Data Source: TMY3
Location: 41.98 °N, 87.92 °W
Distance From Session Location: 11.39 mi

Month	Chicago Main Building Pitch	Chicago, Main Building	Chicago Main Building Middle	Chicago North Wing	Chicago South Wing	Overall
Jan	432.3	498.7	1191.4	1294.7	381.7	3798.8
Feb	526.7	627	1590.9	1768	510.4	5023
Mar	742	906.8	2377.3	2691.5	740.9	7458.5
Apr	824.9	1023.1	2928.1	3084.2	897.9	8758.2
May	1092.5	1378.8	3516.5	4199.4	1074.7	11261.9
Jun	1080	1378.6	3499.8	4243.9	1069.8	11272.1
Jul	1088.2	1383.2	3602.4	4249.8	1100.2	11423.8
Aug	937.9	1167.8	2989.5	3536.7	915.1	9547
Sep	778.9	960.1	2432.7	2866.4	755.7	7793.8
Oct	630.6	751	1917.2	2171.8	610	6080.6
Nov	392.6	463.1	1102.1	1278.5	357.9	3594.2
Dec	365.9	412.4	902.1	1071.7	287.7	3039.8
Annual	8892.6	10950.8	28050.1	32456.7	8702.1	89052.3
# Modules	31	39	98	122	30	320
kWp	8.525	10.725	26.95	33.55	8.25	88



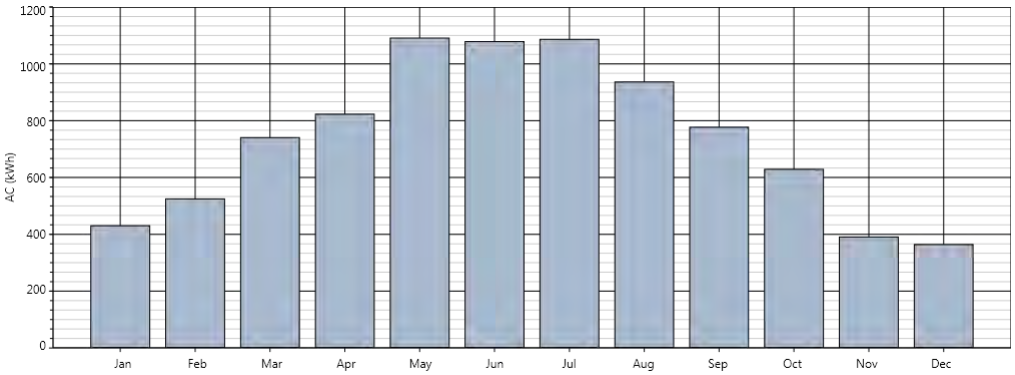
Chicago Main Building Pitch:

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Enphase Energy
Inverter Model: M250
Factor: 0.76

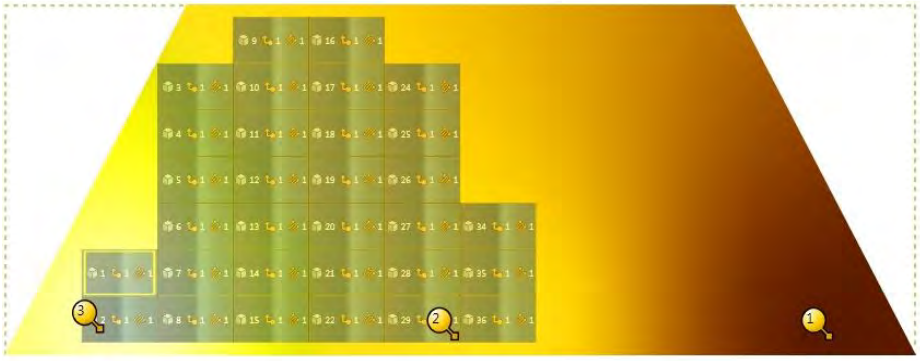
Month	Chicago Main Building Pitch AC (kWh)
Jan	432.3
Feb	526.7
Mar	742.0
Apr	824.9
May	1092.5
Jun	1080.0
Jul	1088.2
Aug	937.9
Sep	778.9
Oct	630.6
Nov	392.6
Dec	365.9
Annual	8892.6

Design Result Chart:



Layout View:

Length: 65.00 ft Width:
24.00 ft Azimuth:
171.00 ° Slope: 16.00 °
Total Modules: 31



Solmetric

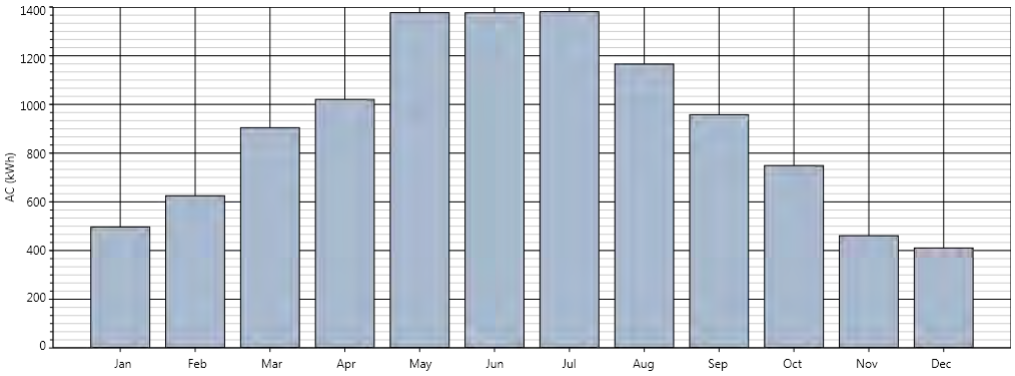
Chicago Main Building (South Side)

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Enphase Energy
Inverter Model: M250
De-rate Factor: 0.76
Module Row Spacing=24”

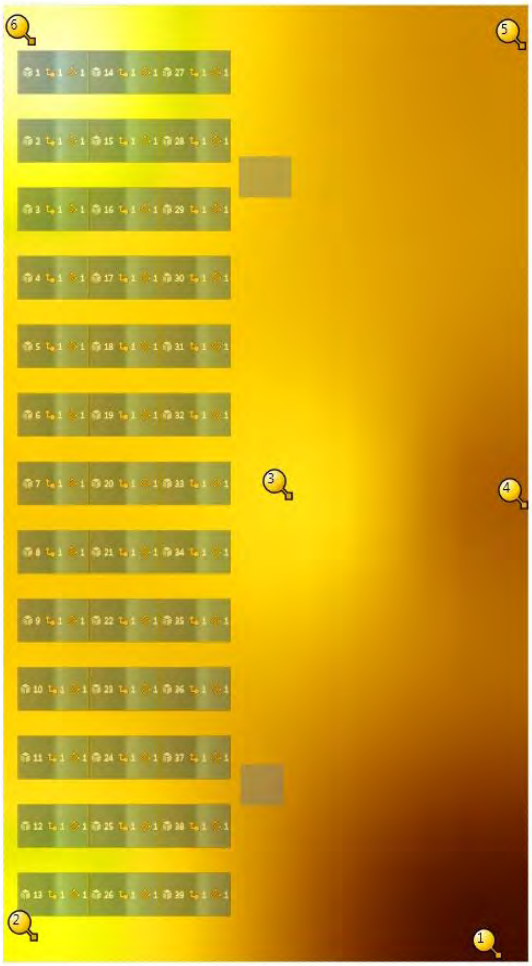
Month	Chicago, Main Building AC (kWh)
Jan	498.7
Feb	627.0
Mar	906.8
Apr	1023.1
May	1378.8
Jun	1378.6
Jul	1383.2
Aug	1167.8
Sep	960.1
Oct	751.0
Nov	463.1
Dec	412.4
Annual	10950.8

Design Result Chart:



Layout View:

Length: 40.00 ft Width:
70.00 ft Azimuth:
171.00 ° Slope: 10.00 °
Total Modules: 39



Solmetric

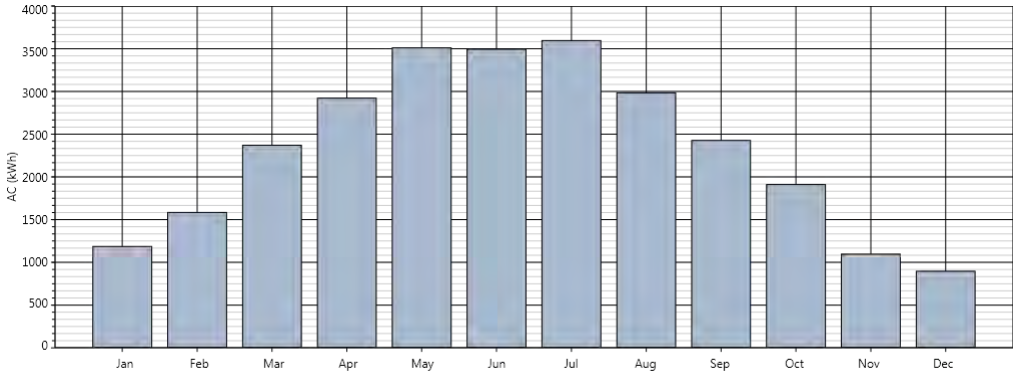
Chicago Main Building Middle

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Enphase Energy
Inverter Model: M250
De-rate Factor: 0.76
Module Row Spacing=24”

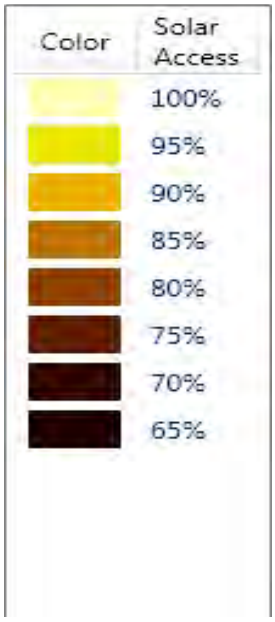
Month	Chicago Main Building Middle AC (kWh)
Jan	1191.4
Feb	1590.9
Mar	2377.3
Apr	2928.1
May	3516.5
Jun	3499.8
Jul	3602.4
Aug	2989.5
Sep	2432.7
Oct	1917.2
Nov	1102.1
Dec	902.1
Annual	28050.1

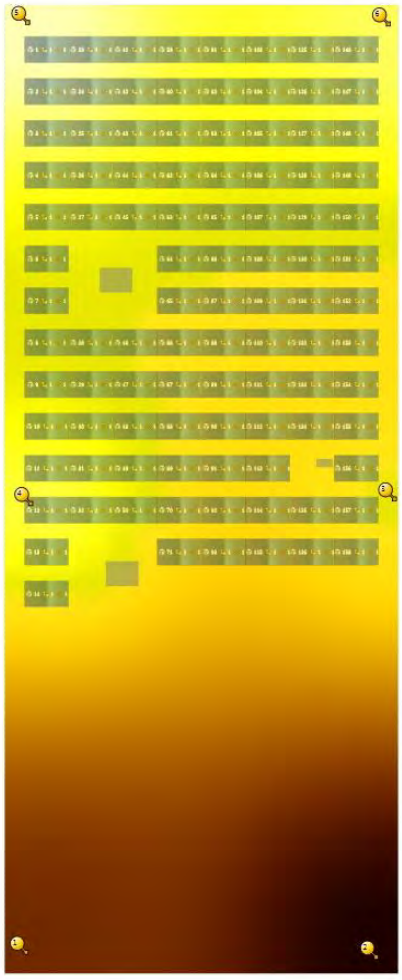
Design Result Chart:



Layout View:

Length: 48.00 ft Width: 116.00 ft Azimuth: 171.00 ° Slope: 10.00 °
Total Modules: 98



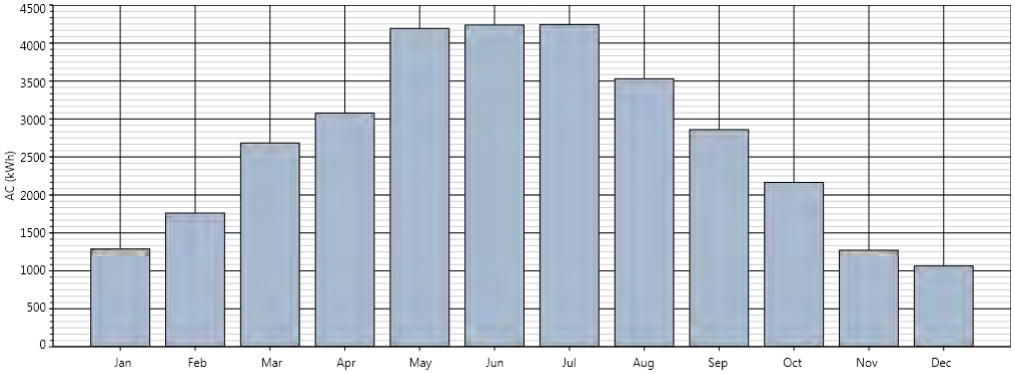


Chicago North Wing

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Enphase Energy
Inverter Model: M250
De-rate Factor: 0.76
Module Row Spacing=24”

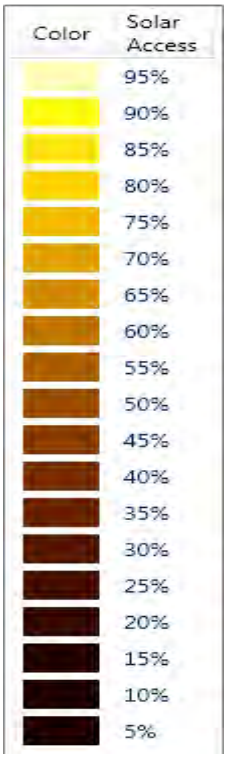
Design Result Chart:

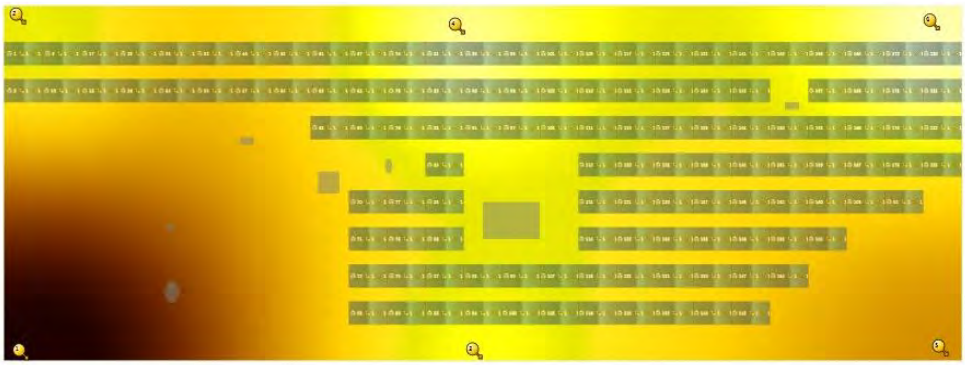


Month	Chicago North Wing AC (kWh)
Jan	1294.7
Feb	1768.0
Mar	2691.5
Apr	3084.2
May	4199.4
Jun	4243.9
Jul	4249.8
Aug	3536.7
Sep	2866.4
Oct	2171.8
Nov	1278.5
Dec	1071.7
Annual	32456.7

Layout View:

Length: 135.00 ft
Width: 48.00 ft
Azimuth: 171.00 °
Slope: 10.00 °
Total Modules: 122





Solmetric

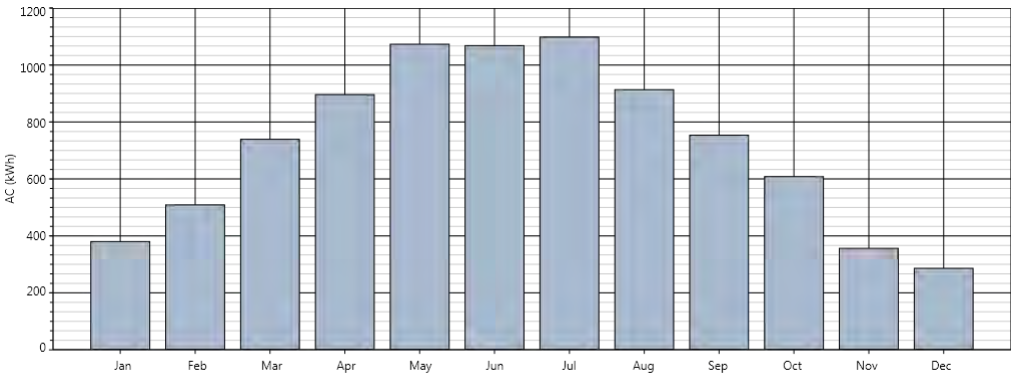
Chicago South Wing

Design Properties:

Module Manufacturer: SolarWorld
Module Model: Protect SW 275 Mono Black
Inverter Manufacturer: Enphase Energy
Inverter Model: M250
De-rate Factor: 0.76
Module Row Spacing=24”

Month	Chicago South Wing AC (kWh)
Jan	381.7
Feb	510.4
Mar	740.9
Apr	897.9
May	1074.7
Jun	1069.8
Jul	1100.2
Aug	915.1
Sep	755.7
Oct	610.0
Nov	357.9
Dec	287.7
Annual	8702.1

Design Result Chart:



Layout View:

Length: 146.00 ft
Width: 165.00 ft
Azimuth: 171.00 °
Slope: 10.00 ° Total
Modules: 30

Solar Access and Shade Report – Chicago Main Building Pitch

Session Properties

Name	chicago main bldg south pitch roof
Creation Date	3/27/2014 8:49
Note	(none)
Location	42.0°N, 87.7°W Mag Dec: 3.8°W Time Zone: GMT-06:00

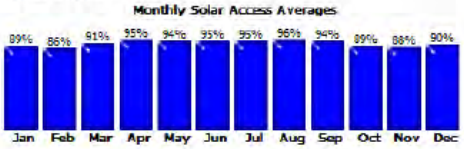
Skylines

- **Sky01 - east side**
- **Sky02 - middle**
- **Sky03 - west side**

Solar access averages of 3 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03

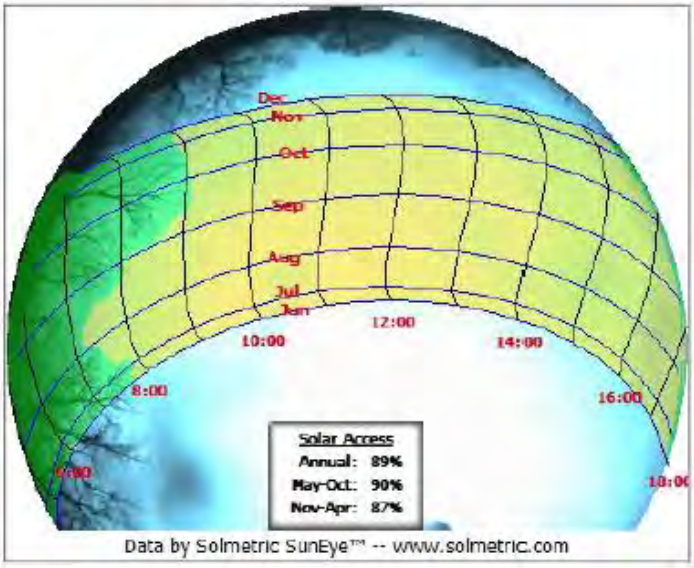
Annual	May-Oct	Nov-Apr
93%	94%	91%

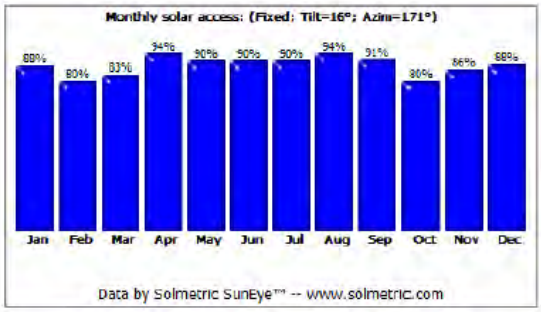


TSRF averages of 3 skylines in this session: 89%

Sky01 -- 3/27/2014 8:52 -- east side

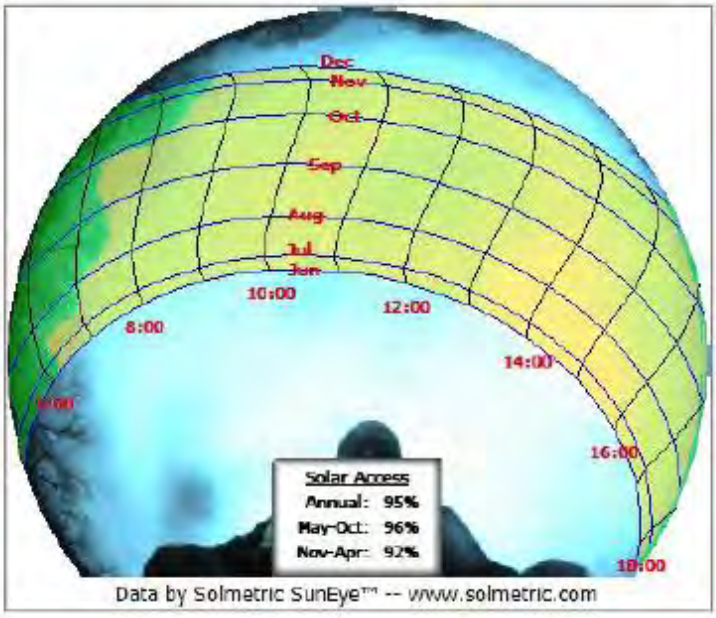
Panel Orientation: Tilt=16° -- Azimuth=171° -- **Skyline Heading=181°**
Solar Access: Annual: 89% -- Summer (May-Oct): 90% -- Winter (Nov-Apr): 87%
TSRF: 85% -- **TOF:** 96%

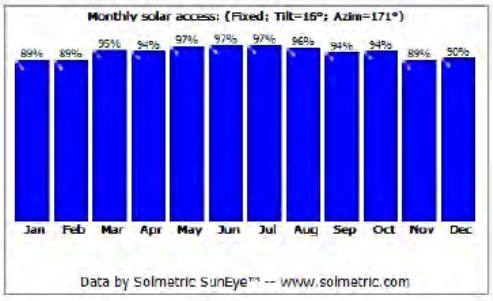



Monthly solar access: (Fixed: Tilt=16°; Azim=171°)
88% 80% 83% 94% 90% 90% 90% 94% 91% 86% 86% 88%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky02 -- 3/27/2014 8:52 -- middle

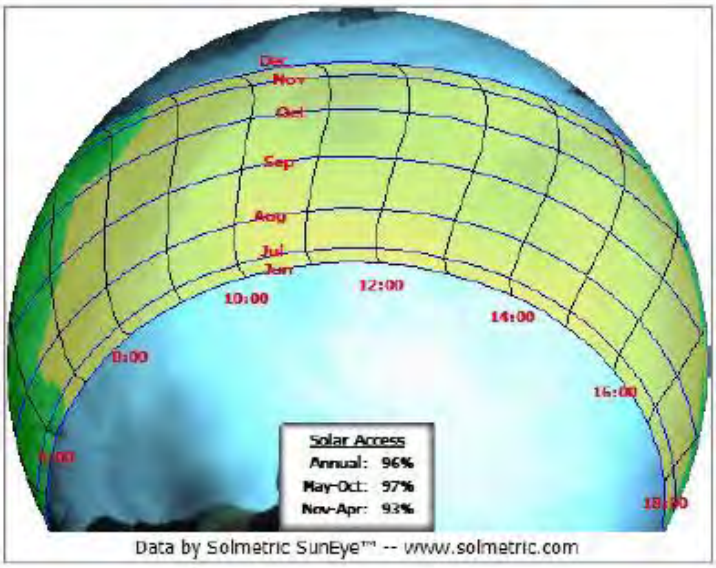
Panel Orientation: Tilt=16° -- Azimuth=171° -- **Skyline Heading=166°**
Solar Access: Annual: 95% -- Summer (May-Oct): 96% -- Winter (Nov-Apr): 92%
TSRF: 91% -- **TOF:** 96%

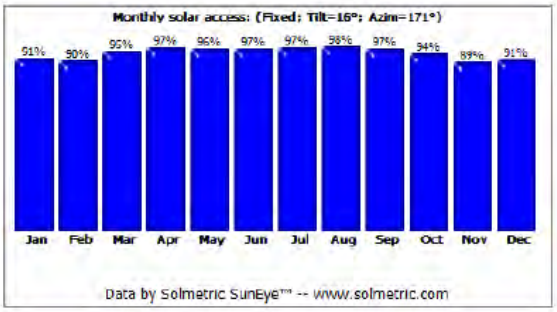



Monthly solar access: (Fixed; Tilt=16°; Azim=171°)
89% 89% 95% 94% 97% 97% 97% 96% 94% 94% 89% 90%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky03 -- 3/27/2014 8:54 -- west side

Panel Orientation: Tilt=16° -- Azimuth=171° -- **Skyline Heading=177°**
Solar Access: Annual: 96% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 93%
TSRF: 92% -- **TOF:** 96%




Monthly solar access: (Fixed; Tilt=16°; Azim=171°)
91% 90% 95% 97% 96% 97% 97% 98% 97% 94% 89% 91%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Solar Access and Shade Report – Chicago Main Building (South Side)

Session Properties

Name	chicago main bldg south side
Creation Date	3/27/2014 8:39
Note	(none)
Location	42.0°N, 87.7°W Mag Dec: 3.8°W Time Zone: GMT-06:00

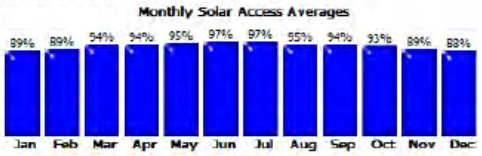
Skylines

- **Sky01 - south east corner**
- **Sky02 - south west corner**
- **Sky03 - middle**
- **Sky04 - middle east side**
- **Sky05 - north east corner**
- **Sky06 - north west corner**

Solar access averages of 6 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06

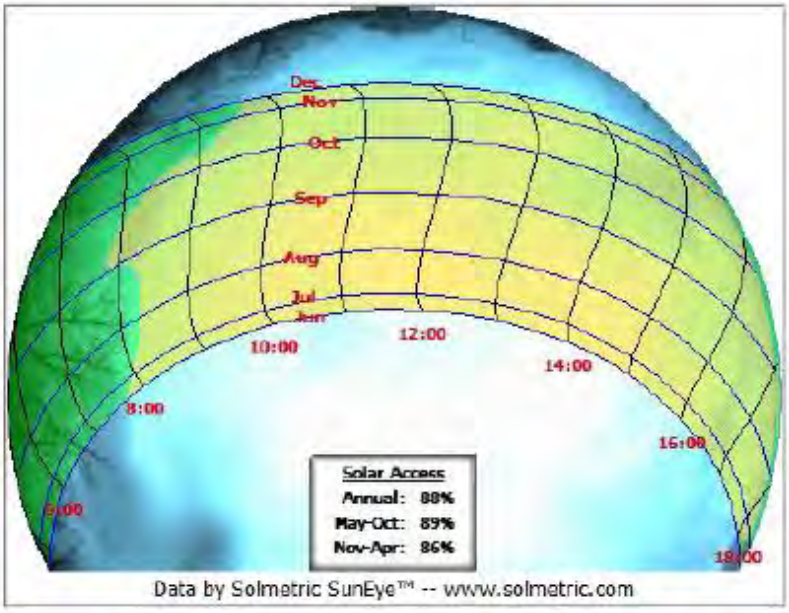
Annual	May-Oct	Nov-Apr
94%	95%	91%

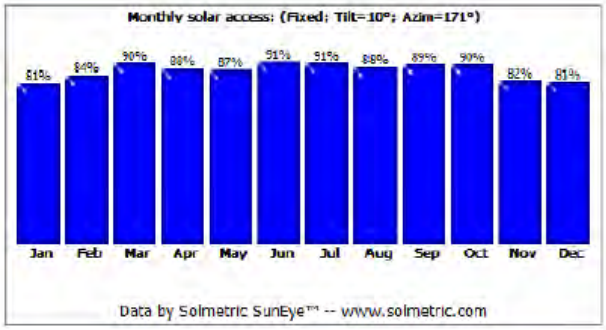


TSRF averages of 6 skylines in this session: 88%

Sky01 -- 3/27/2014 8:41 -- south east corner

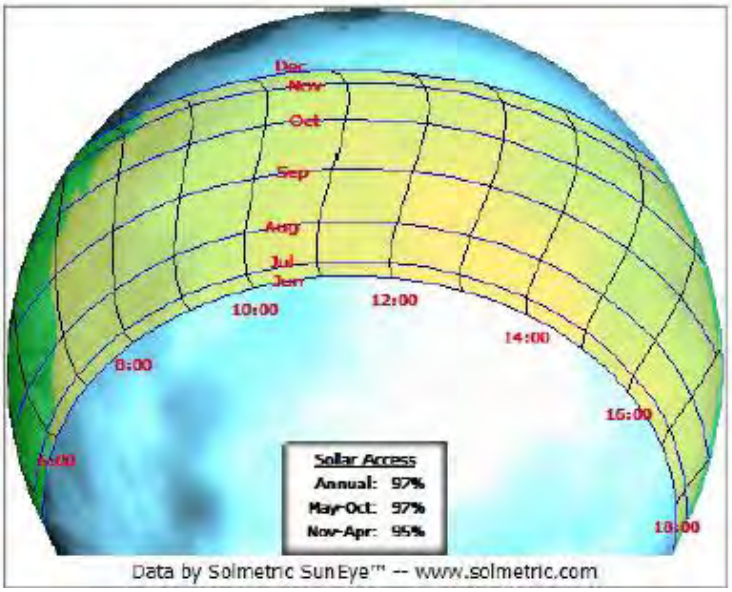
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=178°**
Solar Access: Annual: 88% -- Summer (May-Oct): 89% -- Winter (Nov-Apr): 86%
TSRF: 82% -- **TOF:** 93%

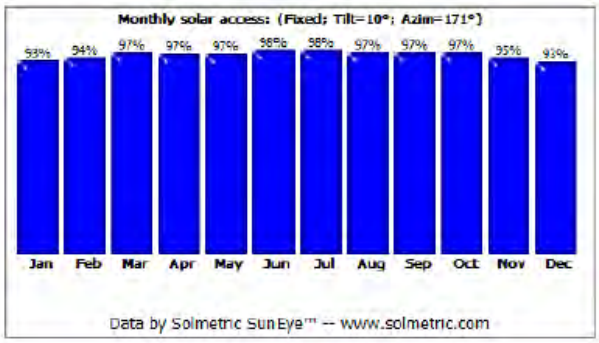



Monthly solar access: (Fixed: Tilt=10°; Azim=171°)
81% 84% 90% 88% 87% 91% 91% 88% 89% 90% 82% 81%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky02 -- 3/27/2014 8:42 -- south west corner

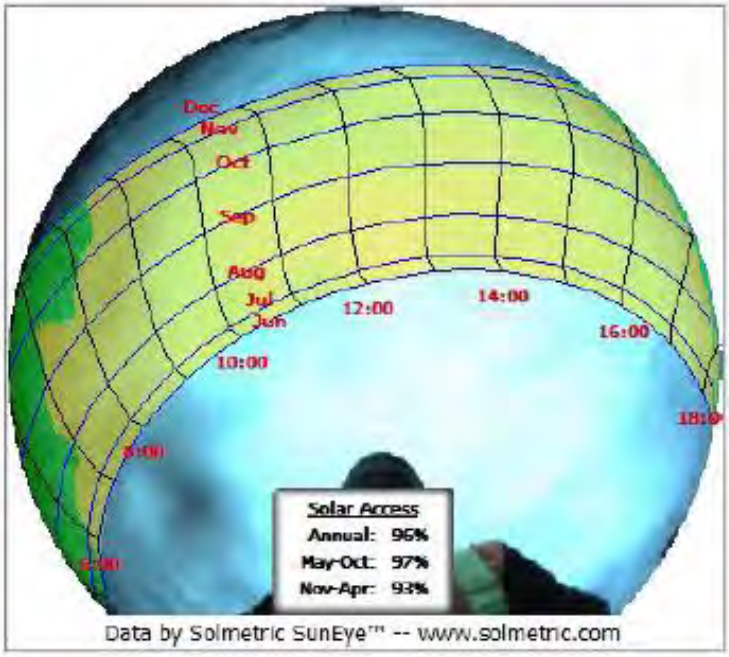
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=176°**
Solar Access: Annual: 97% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 95%
TSRF: 90% -- **TOF:** 93%

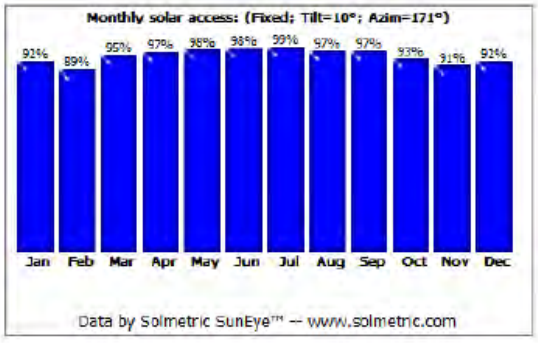



Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
93% 94% 97% 97% 97% 98% 98% 97% 97% 97% 95% 93%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky03 -- 3/27/2014 8:44 -- middle

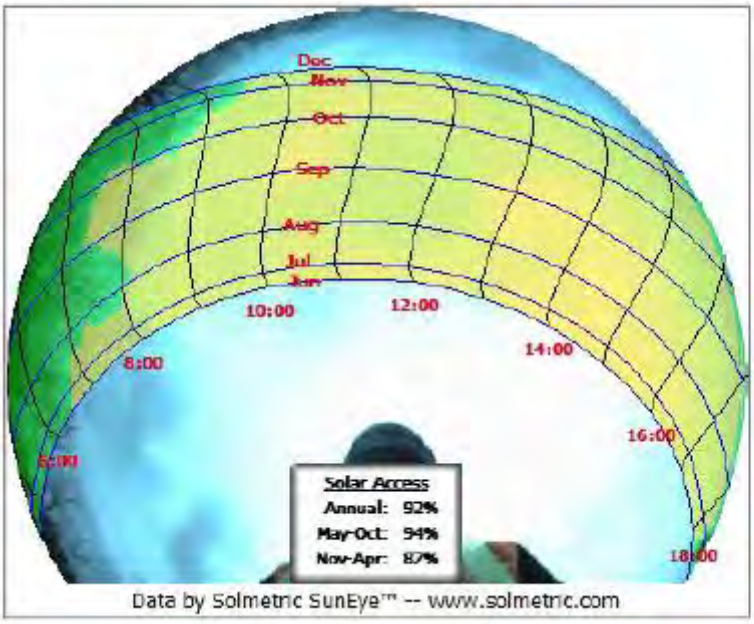
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=195°**
Solar Access: Annual: 96% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 93%
TSRF: 90% -- **TOF:** 93%

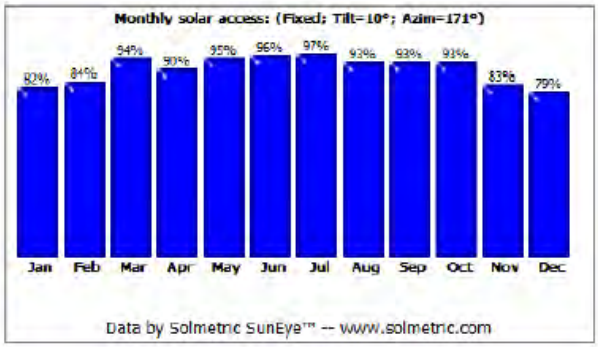



Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
92% 89% 95% 97% 98% 98% 99% 97% 97% 93% 91% 92%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky04 -- 3/27/2014 8:45 -- middle east side

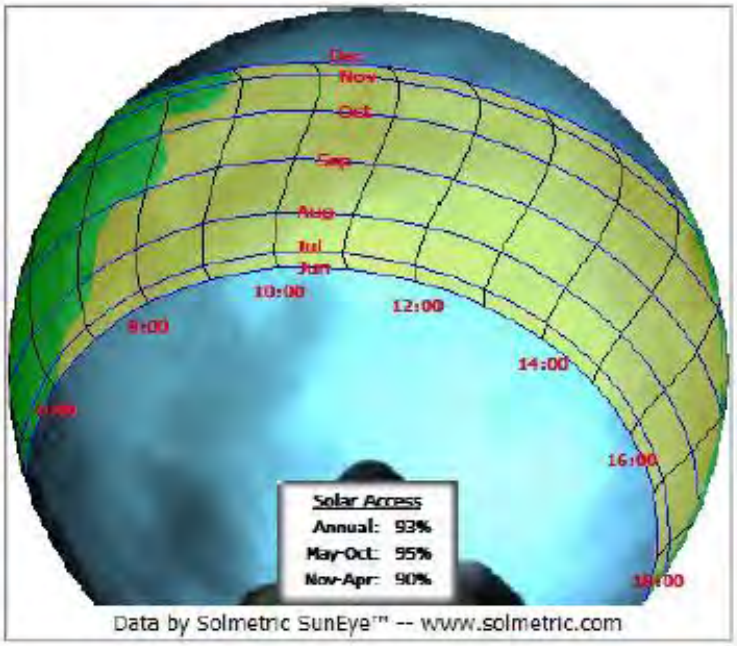
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=173°**
Solar Access: Annual: 92% -- Summer (May-Oct): 94% -- Winter (Nov-Apr): 87%
TSRF: 86% -- **TOF:** 93%

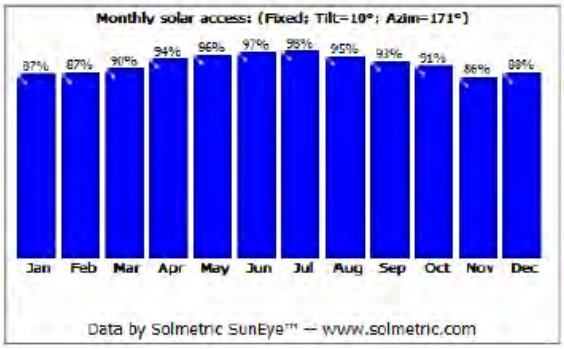




Sky05 -- 3/27/2014 8:45 -- north east corner

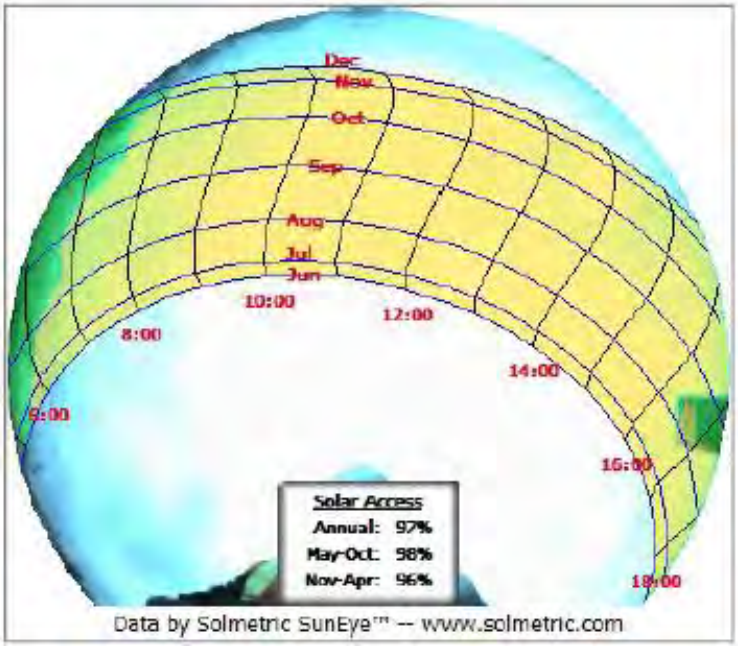
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=166°**
Solar Access: Annual: 93% -- Summer (May-Oct): 95% -- Winter (Nov-Apr): 90%
TSRF: 87% -- **TOF:** 93%

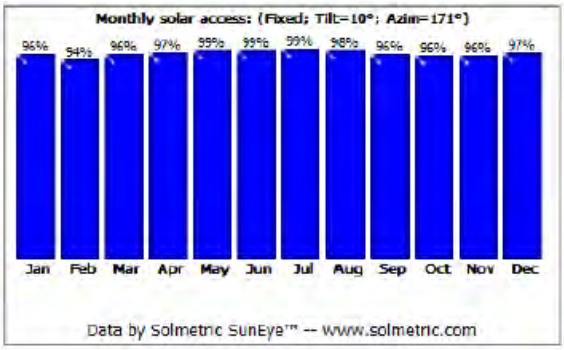




Sky06 -- 3/27/2014 8:46 -- north west corner

Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=166°**
Solar Access: Annual: 97% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 96%
TSRF: 91% -- **TOF:** 93%




Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
96% 94% 96% 97% 99% 99% 99% 98% 96% 96% 96% 97%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Solar Access and Shade Report – Chicago Main Middle

Session Properties

Name	chicago main bldg middle roof
Creation Date	3/27/2014 8:19
Note	(none)
Location	42.0°N, 87.7°W Mag Dec: 3.8°W Time Zone: GMT-06:00

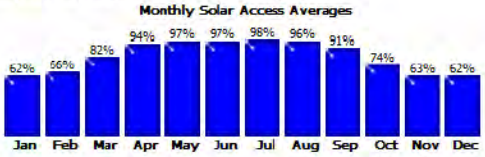
Skylines

- **Sky01 - south west corner**
- **Sky02 - south east corner**
- **Sky03 - east middle**
- **Sky04 - west middle**
- **Sky05 - north west corner**
- **Sky06 - north east corner**

Solar access averages of 6 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06

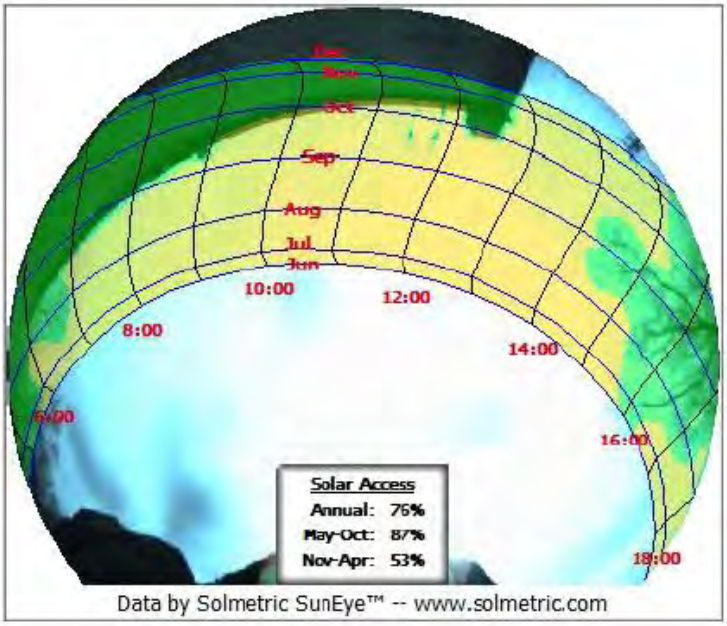
Annual	May-Oct	Nov-Apr
88%	93%	76%

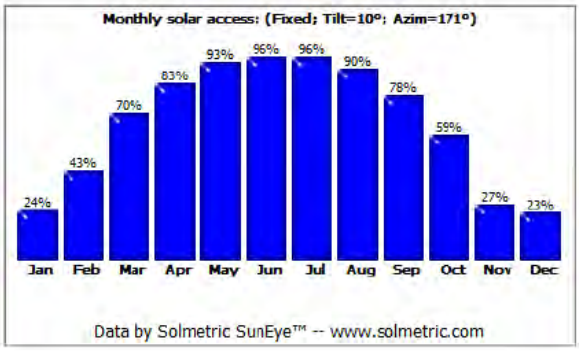


TSRF averages of 6 skylines in this session: 82%

Sky01 -- 3/27/2014 8:22 -- south west corner

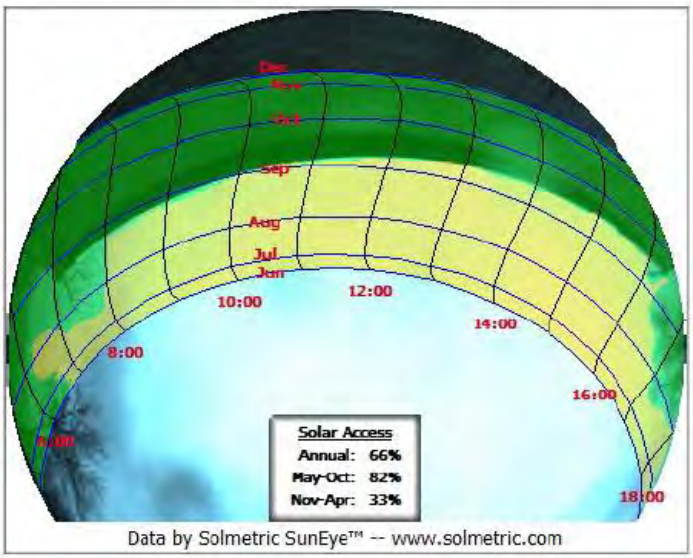
Panel Orientation: Tilt=10° – Azimuth=171° – **Skyline Heading=168°**
Solar Access: Annual: 76% – Summer (May-Oct): 87% -- Winter (Nov-Apr): 53%
TSRF: 71% – **TOF:** 93%

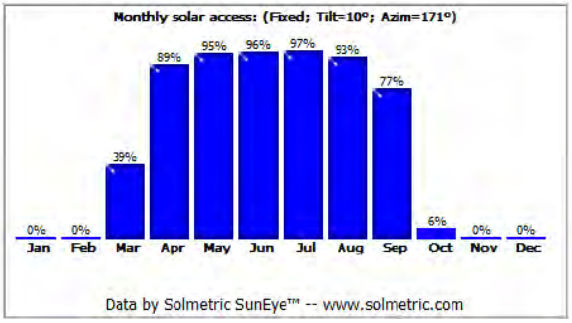




Sky02 -- 3/27/2014 8:23 -- south east corner

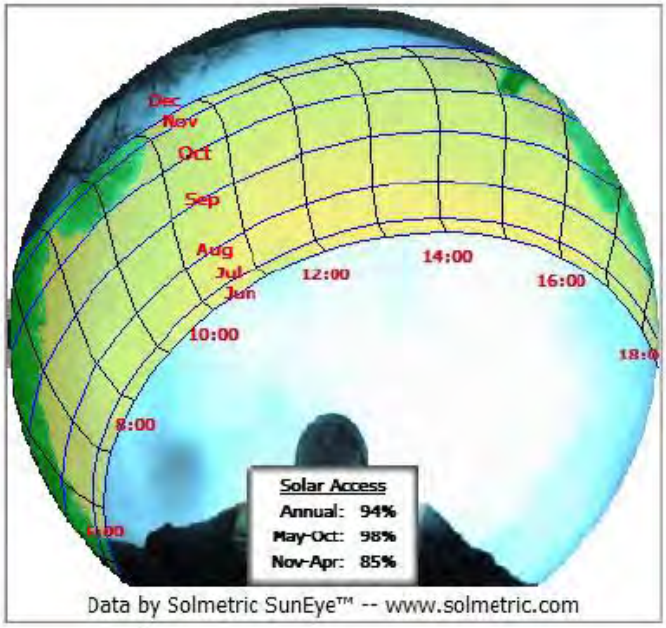
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=176°**
Solar Access: Annual: 66% -- Summer (May-Oct): 82% -- Winter (Nov-Apr): 33%
TSRF: 62% -- **TOF:** 93%

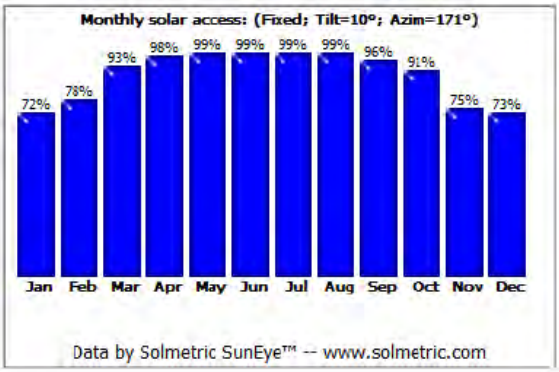




Sky03 -- 3/27/2014 8:25 -- east middle

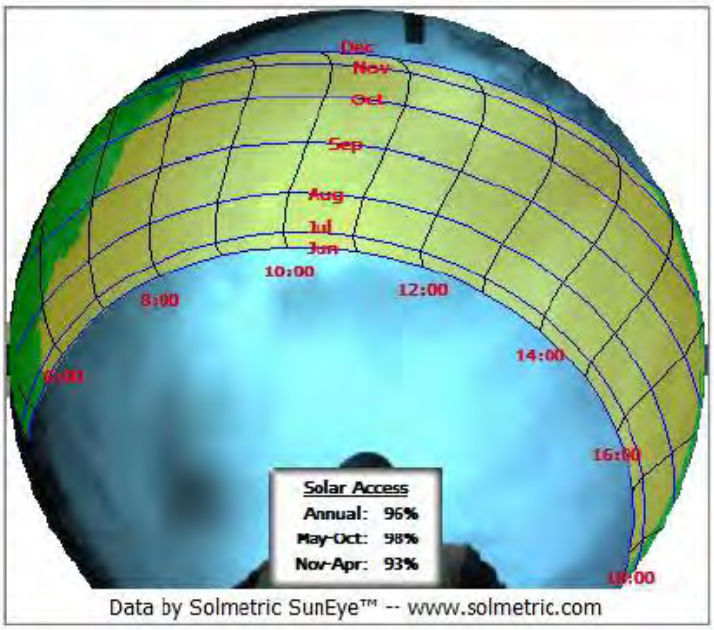
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=200°**
Solar Access: Annual: 94% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 85%
TSRF: 87% -- **TOF:** 93%

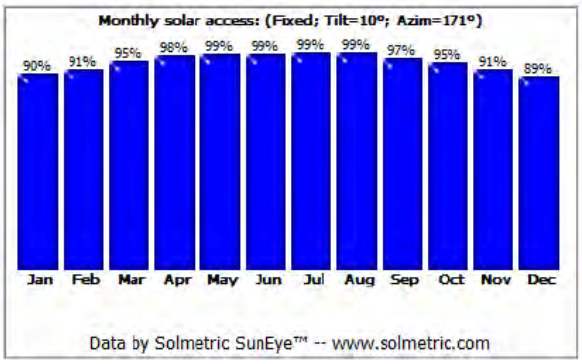




Sky04 -- 3/27/2014 8:28 -- west middle

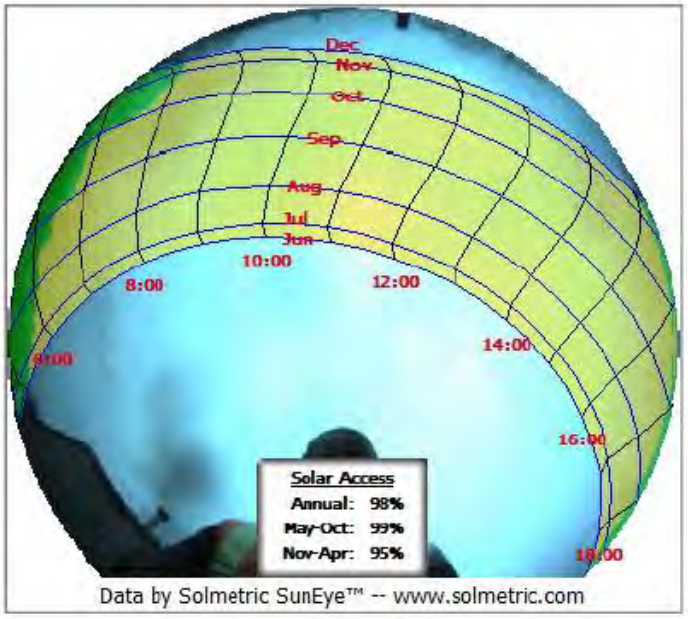
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=163°**
Solar Access: Annual: 96% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 93%
TSRF: 90% -- **TOF:** 93%

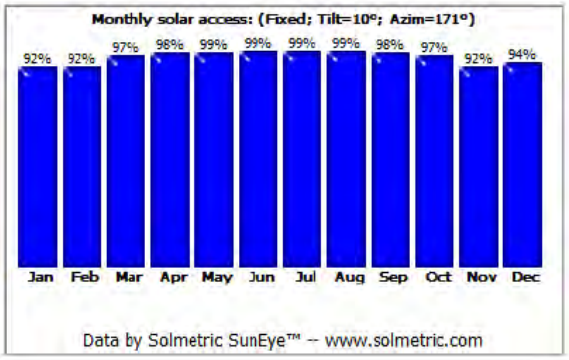



Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
90% 91% 95% 98% 99% 99% 99% 99% 97% 95% 91% 89%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky05 -- 3/27/2014 8:31 -- north west corner

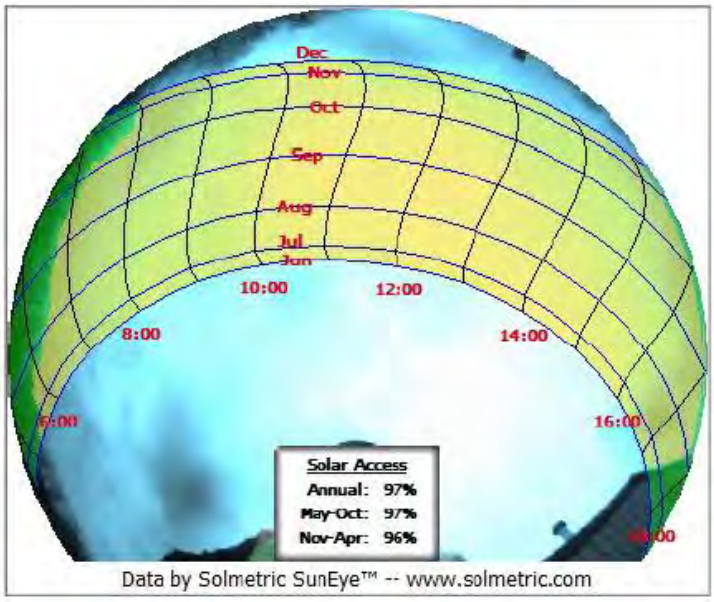
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=162°**
Solar Access: Annual: 98% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 95%
TSRF: 91% -- **TOF:** 93%

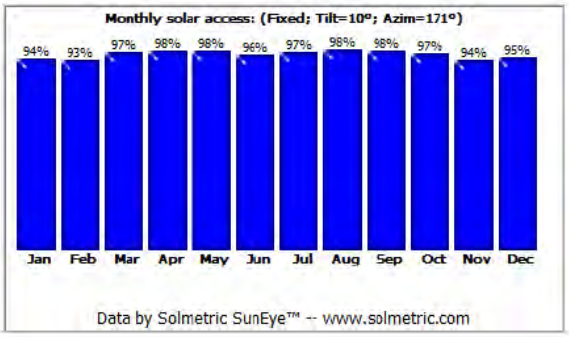



Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
92% 92% 97% 98% 99% 99% 99% 99% 98% 97% 92% 94%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky06 -- 3/27/2014 8:32 -- north east corner

Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=171°**
Solar Access: Annual: 97% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 96%
TSRF: 90% -- **TOF:** 93%




Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
94% 93% 97% 98% 98% 96% 97% 98% 98% 97% 94% 95%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Solar Access and Shade Report – Chicago North Wing

Session Properties

Name	chicago north wing
Creation Date	3/27/2014 7:43
Note	(none)
Location	42.0°N, 87.7°W Mag Dec: 3.8°W Time Zone: GMT-06:00

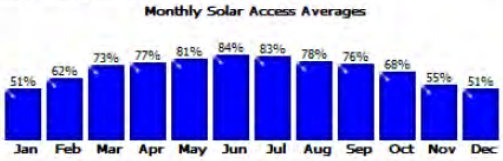
Skylines

- **Sky01 - north wing southwest corner**
- **Sky02 - north wing north west corner**
- **Sky03 - north wing middle south side**
- **Sky04 - north wing middle north side**
- **Sky05 - north wing south east corner**
- **Sky06 - north wing north east corner**

Solar access averages of 6 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06

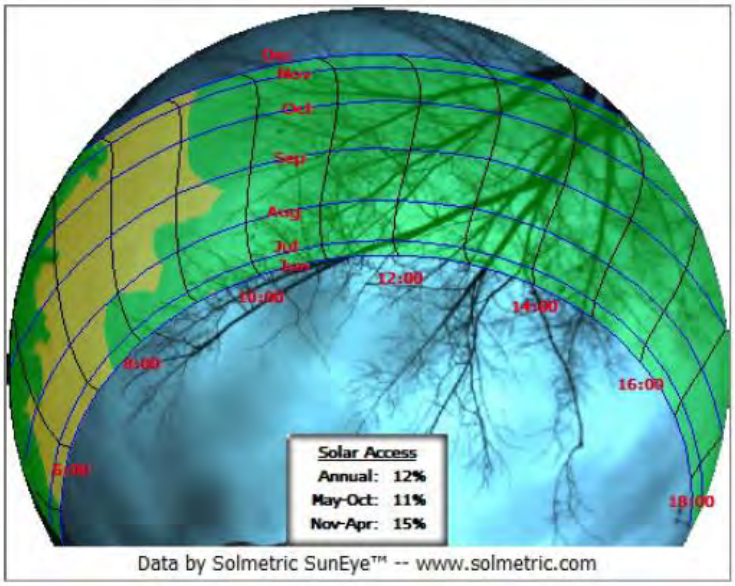
Annual	May-Oct	Nov-Apr
74%	79%	65%

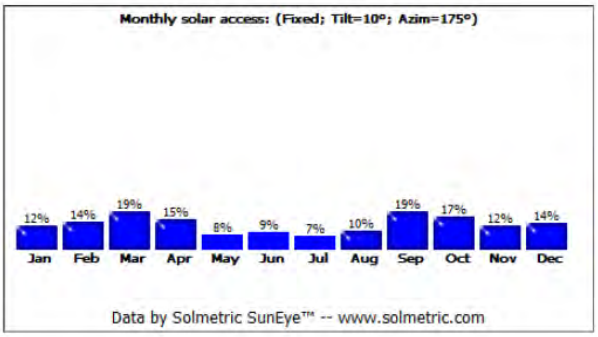


TSRF averages of 6 skylines in this session: 69%

Sky01 -- 3/27/2014 7:45 -- north wing southwest corner

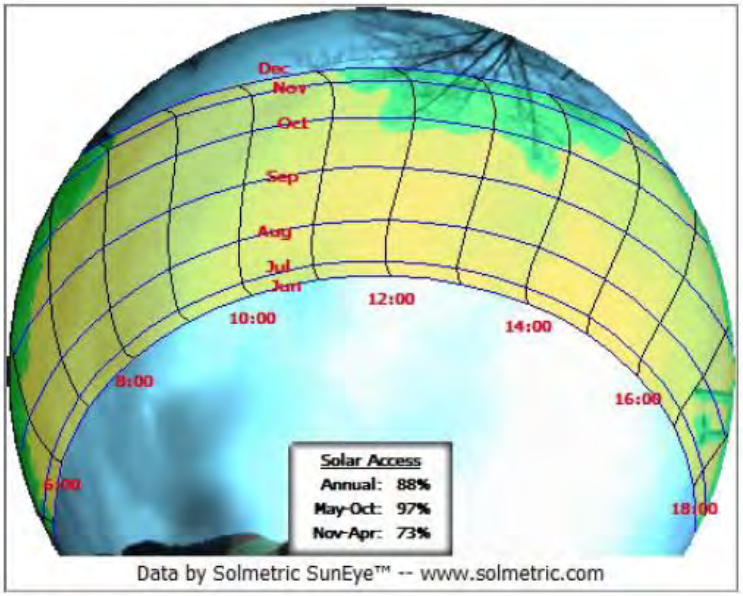
Panel Orientation: Tilt=10° -- Azimuth=175° -- **Skyline Heading=179°**
Solar Access: Annual: 12% -- Summer (May-Oct): 11% -- Winter (Nov-Apr): 15%
TSRF: 11% -- **TOF:** 92%

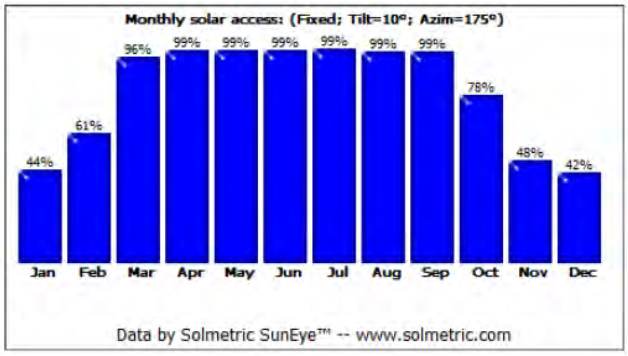




Sky02 -- 3/27/2014 7:47 -- north wing north west corner

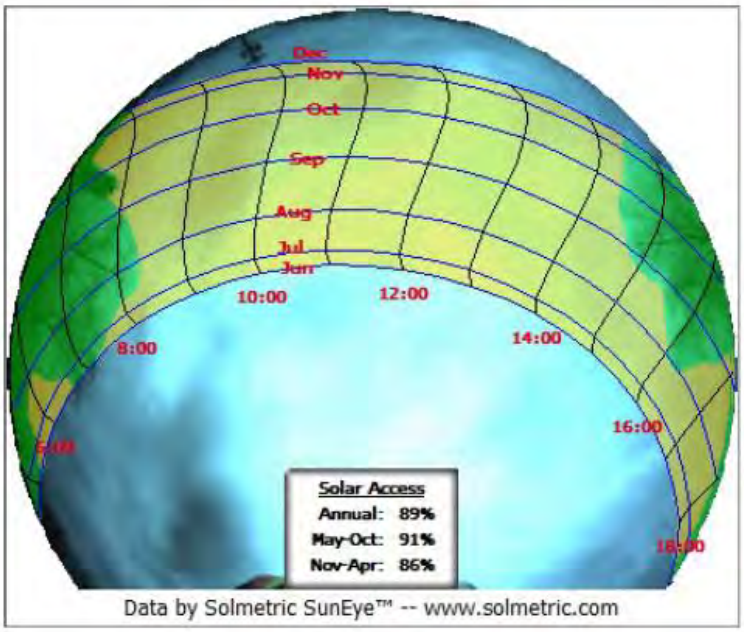
Panel Orientation: Tilt=10° -- Azimuth=175° -- **Skyline Heading=179°**
Solar Access: Annual: 88% -- Summer (May-Oct): 97% -- Winter (Nov-Apr): 73%
TSRF: 82% -- **TOF:** 92%

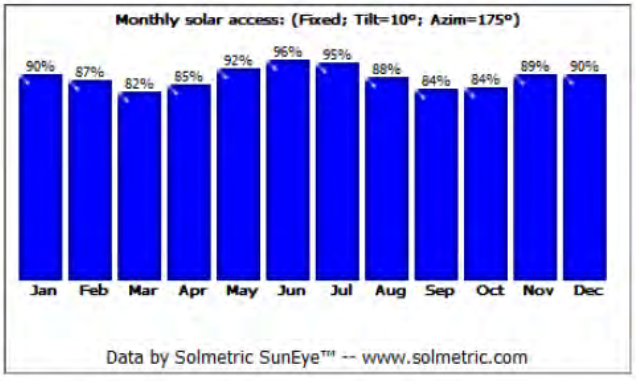




Sky03 -- 3/27/2014 7:49 -- north wing middle south side

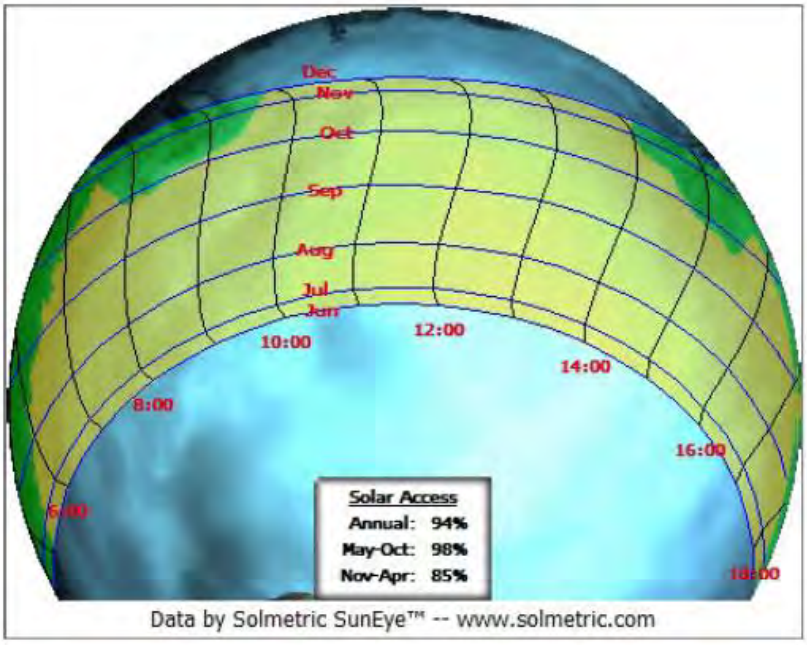
Panel Orientation: Tilt=10° -- Azimuth=175° -- **Skyline Heading=173°**
Solar Access: Annual: 89% -- Summer (May-Oct): 91% -- Winter (Nov-Apr): 86%
TSRF: 82% -- **TOF:** 92%

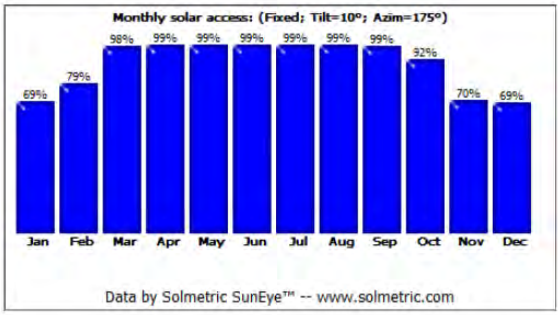




Sky04 -- 3/27/2014 7:51 -- north wing middle north side

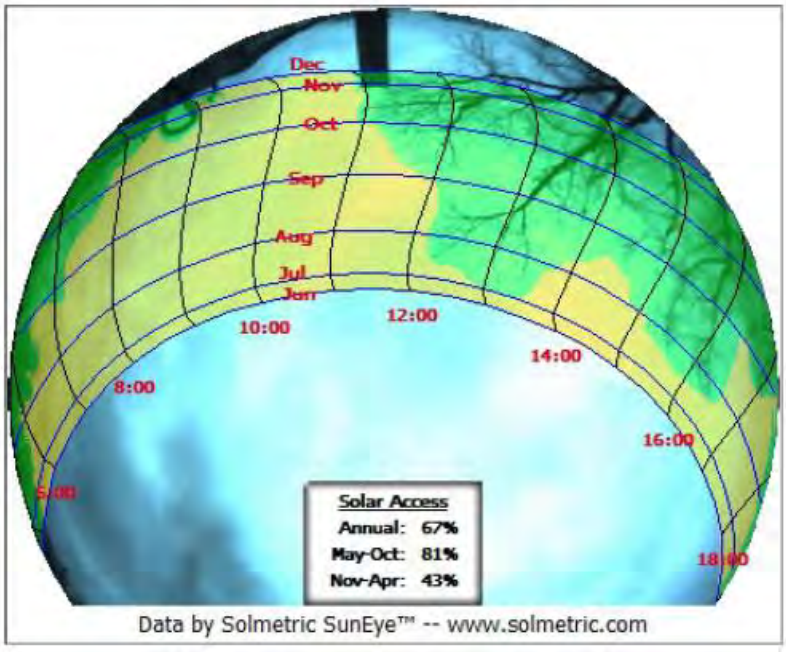
Panel Orientation: Tilt=10° -- Azimuth=175° -- **Skyline Heading=177°**
Solar Access: Annual: 94% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 85%
TSRF: 86% -- **TOF:** 92%

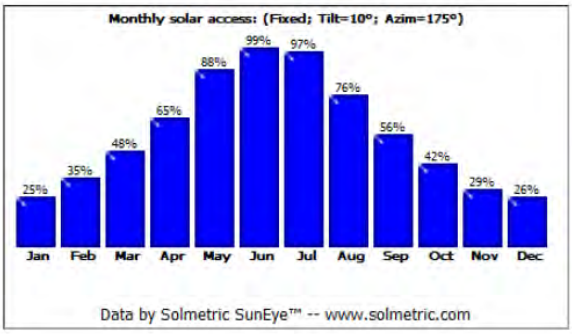




Sky05 -- 3/27/2014 7:53 -- north wing south east corner

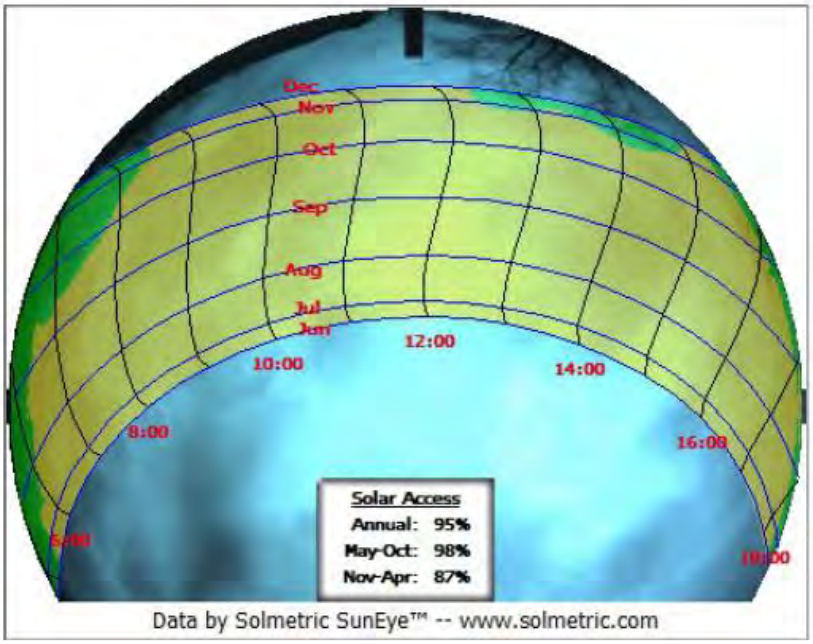
Panel Orientation: Tilt=10° -- Azimuth=175° -- **Skyline Heading=176°**
Solar Access: Annual: 67% -- Summer (May-Oct): 81% -- Winter (Nov-Apr): 43%
TSRF: 62% -- **TOF:** 92%

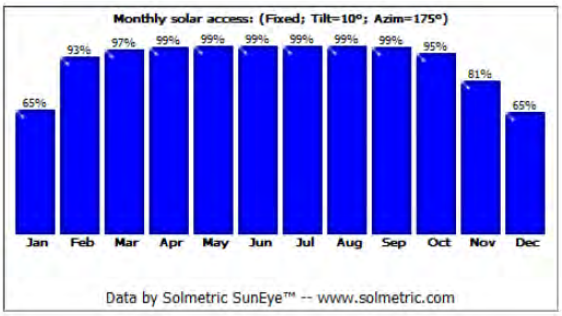




Sky06 -- 3/27/2014 7:54 -- north wing north east corner

Panel Orientation: Tilt=10° -- Azimuth=175° -- **Skyline Heading=180°**
Solar Access: Annual: 95% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 87%
TSRF: 87% -- **TOF:** 92%





Solar Access and Shade Report – Chicago South Wing

Session Properties

Name	chicago south wing
Creation Date	3/27/2014 8:04
Note	(none)
Location	42.0°N, 87.7°W Mag Dec: 3.8°W Time Zone: GMT-06:00

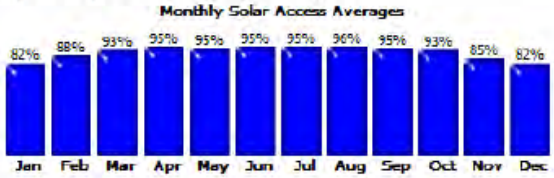
Skylines

- **Sky01 - south west corner**
- **Sky02 - south side middle**
- **Sky03 - north west corner**
- **Sky04 - north middle**
- **Sky05 - north east corner**
- **Sky06 - south east corner**

Solar access averages of 6 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04, Sky05, Sky06

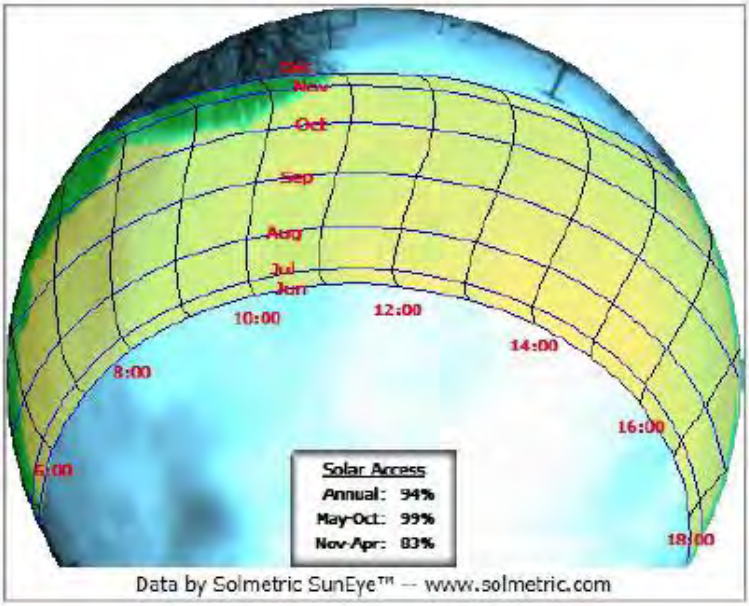
Annual	May-Oct	Nov-Apr
93%	95%	89%

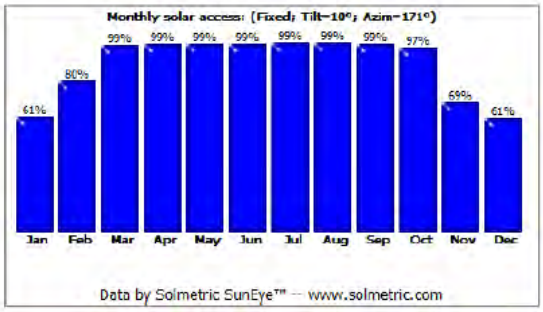


TSRF averages of 6 skylines in this session: 87%

Sky01 -- 3/27/2014 8:06 -- south west corner

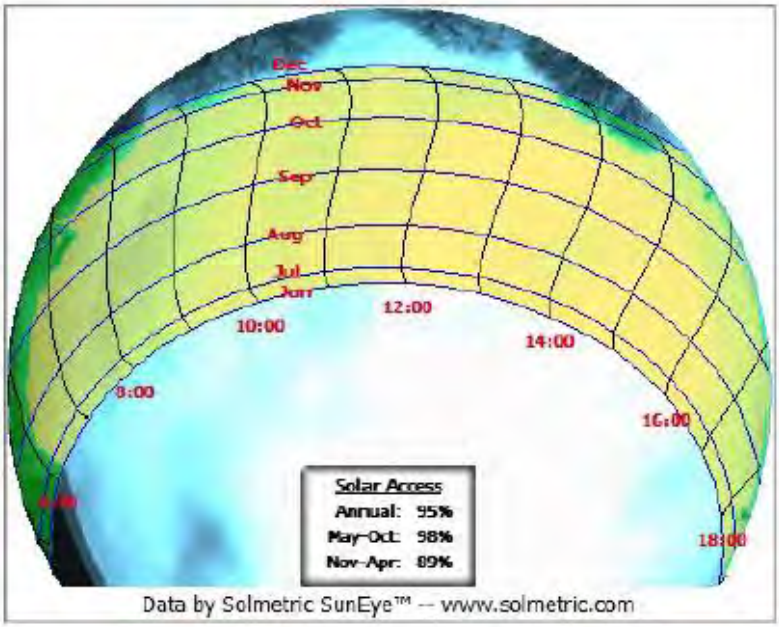
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=175°**
Solar Access: Annual: 94% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 83%
TSRF: 88% -- **TOF:** 93%

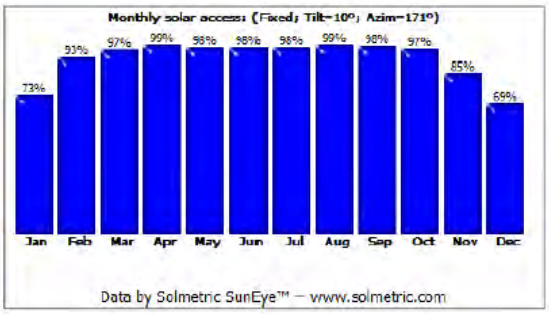




Sky02 -- 3/27/2014 8:08 -- south side middle

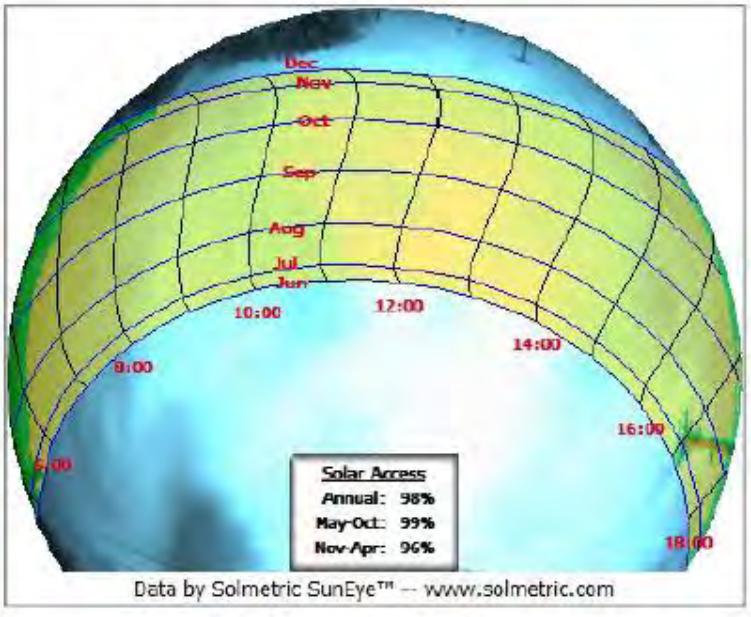
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=178°**
Solar Access: Annual: 95% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 89%
TSRF: 89% -- **TOF:** 93%

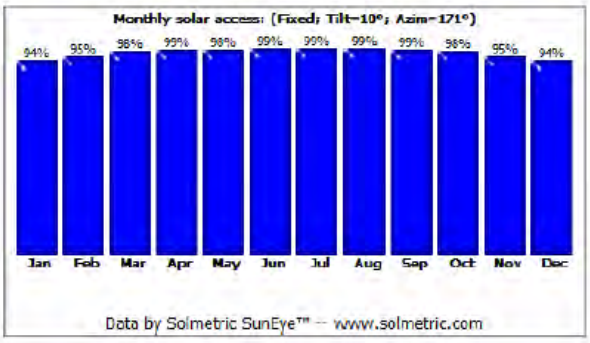




Sky03 -- 3/27/2014 8:09 -- north west corner

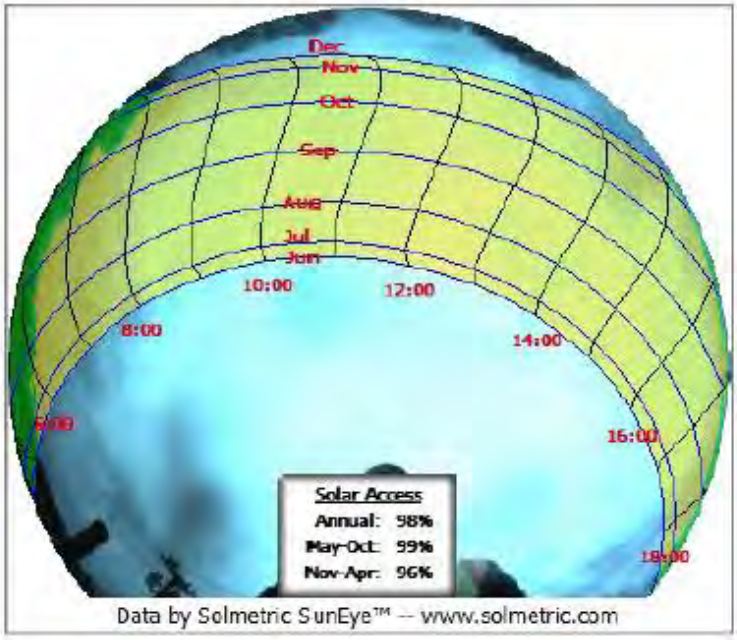
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=175°**
Solar Access: Annual: 98% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 96%
TSRF: 91% -- **TOF:** 93%

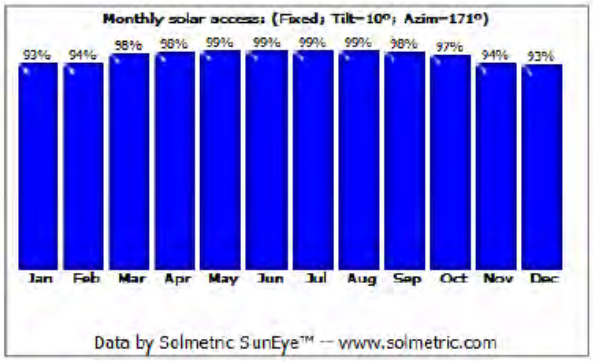




Sky04 -- 3/27/2014 8:10 -- north middle

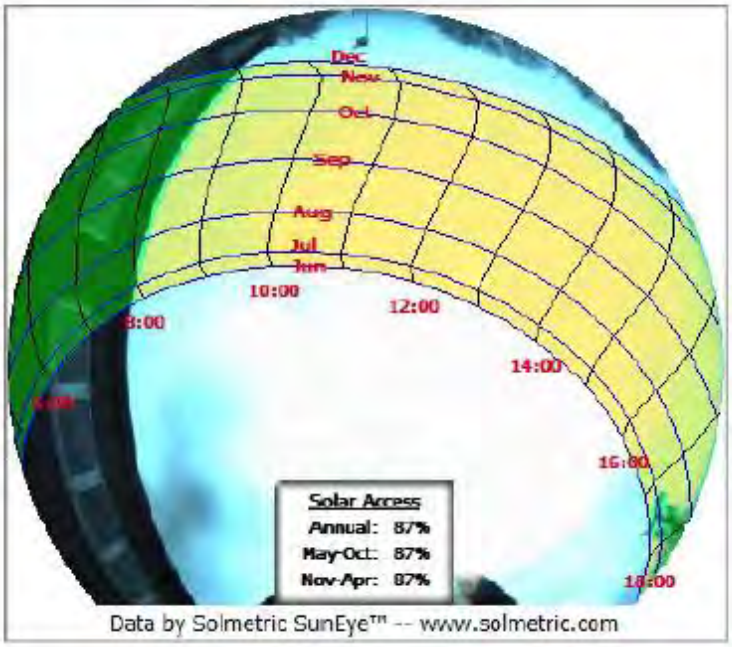
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=169°**
Solar Access: Annual: 98% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 96%
TSRF: 91% -- **TOF:** 93%

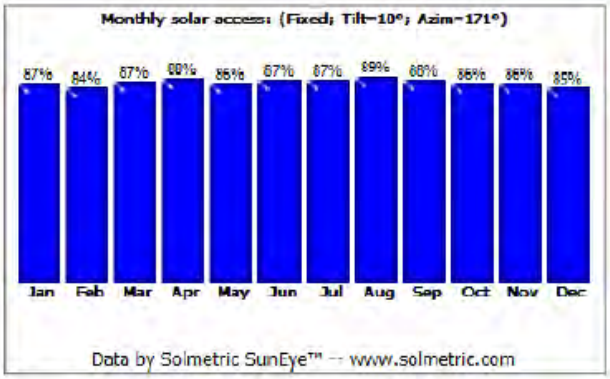



Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
93% 94% 98% 98% 99% 99% 99% 99% 98% 97% 94% 93%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Sky05 -- 3/27/2014 8:12 -- north east corner

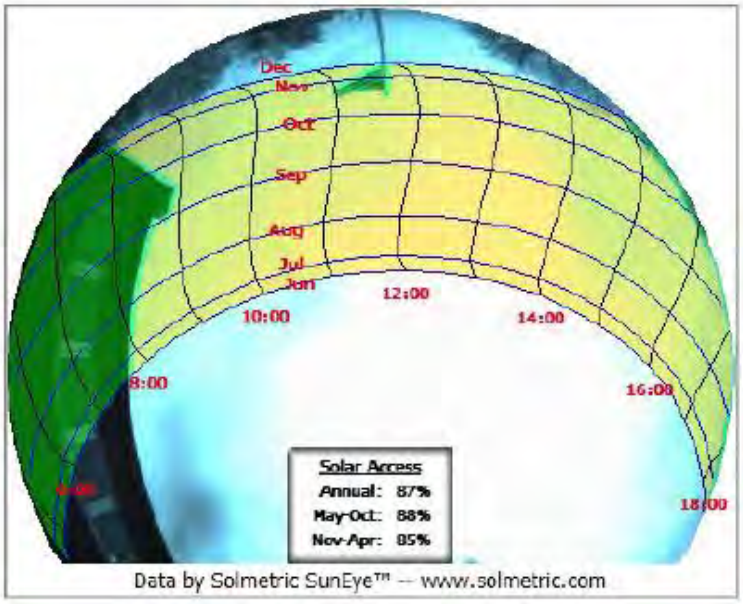
Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=165°**
Solar Access: Annual: 87% -- Summer (May-Oct): 87% -- Winter (Nov-Apr): 87%
TSRF: 81% -- **TOF:** 93%

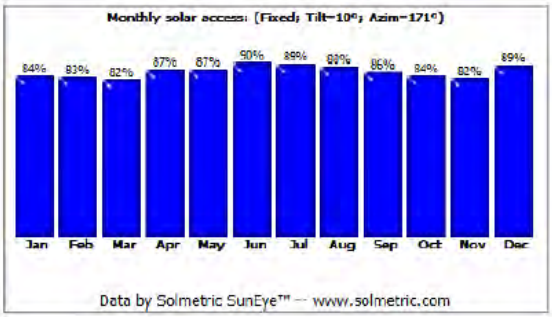



Monthly solar access: (Fixed; Tilt=10°; Azim=171°)
87% 84% 87% 88% 86% 87% 87% 89% 88% 86% 86% 85%
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Data by Solmetric SunEye™ -- www.solmetric.com

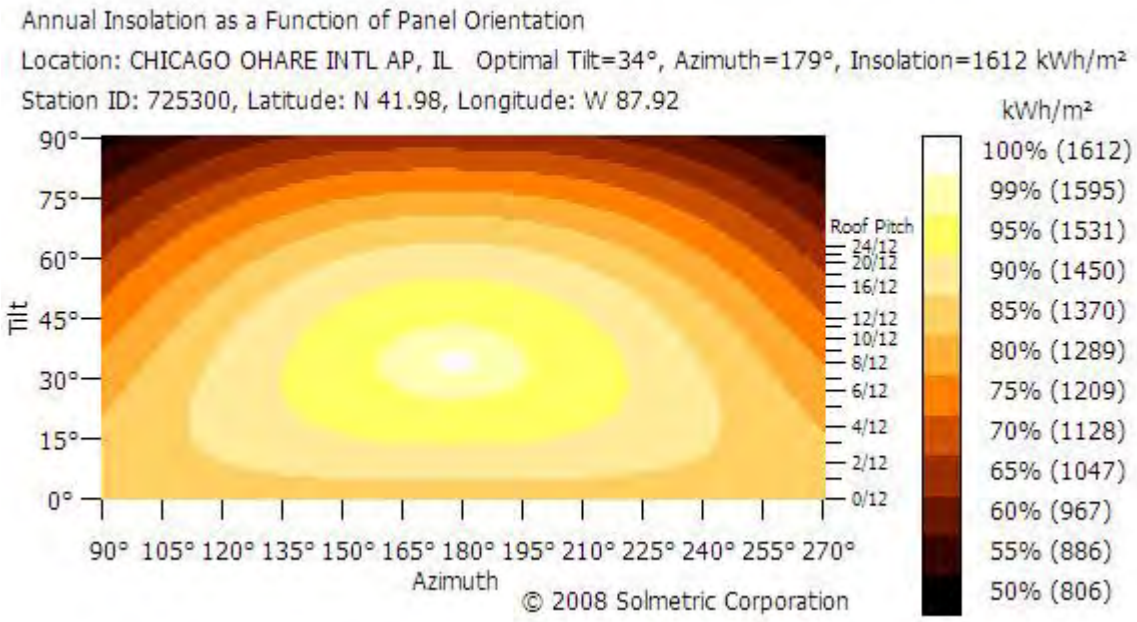
Sky06 – 3/27/2014 8:13 -- south east corner

Panel Orientation: Tilt=10° -- Azimuth=171° -- **Skyline Heading=181°**
Solar Access: Annual: 87% -- Summer (May-Oct): 88% -- Winter (Nov-Apr): 85%
TSRF: 81% -- **TOF:** 93%

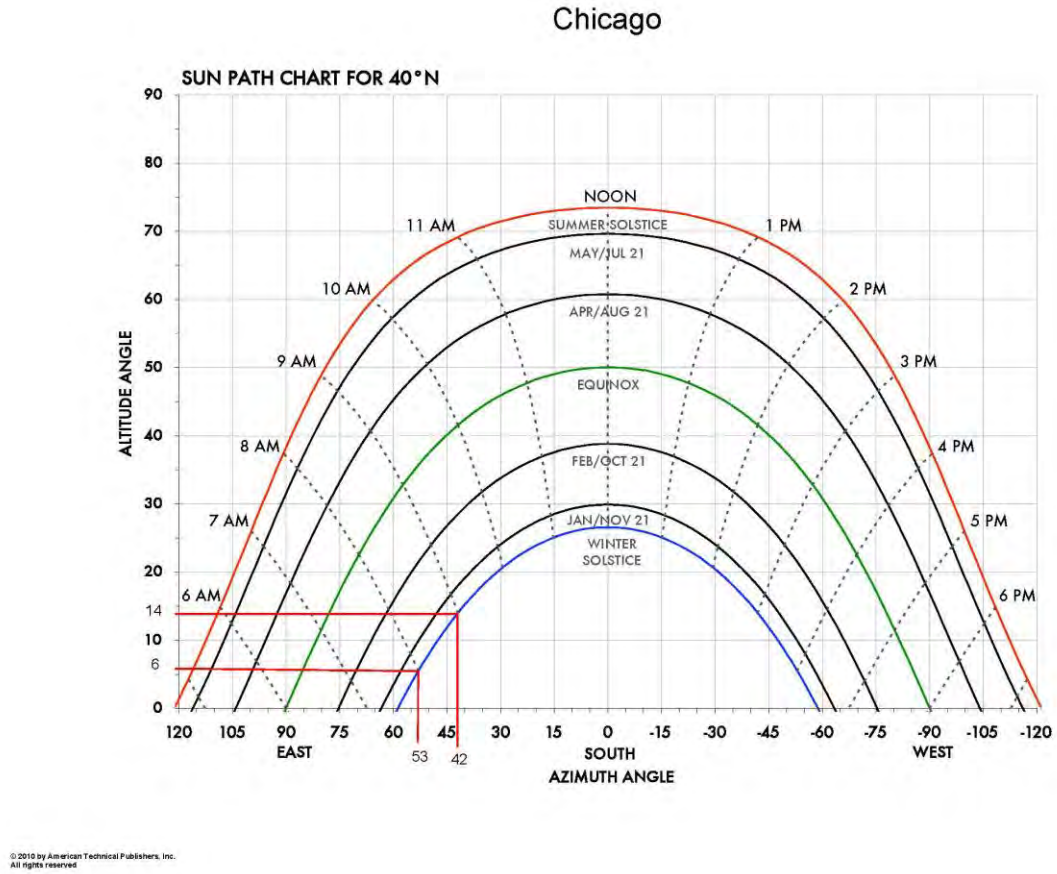




Supporting Data for PV Design in Chicago



Annual Insolation data above indicates that a panel facing south will produce the highest kWH production facing 180° south for the Chicago Area.



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Solar Path for the Chicago Area. Red-line mark-ups were used to calculate PV panel spacing for flat roof application.

CHICAGO, IL (41.8°N, 87.8°W)

Elevation: 190 m Pressure: 992 mb

SOLAR RADIATION FOR FLAT-PLATE COLLECTORS FACING SOUTH AT A FIXED TILT*

Tilt		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0°	Average	1.8	2.6	3.5	4.6	5.7	6.3	6.1	5.4	4.2	3.0	1.8	1.5	3.9
	Minimum	1.5	2.2	3.1	4.0	4.8	5.7	5.4	4.8	3.6	2.5	1.4	1.2	3.7
	Maximum	2.1	3.0	3.9	5.3	6.8	7.2	6.6	6.1	4.9	3.5	2.1	1.7	4.2
Lat – 15°	Average	2.7	3.5	4.1	5.0	5.8	6.1	6.1	5.7	4.9	3.9	2.5	2.2	4.4
	Minimum	2.0	2.8	3.6	4.2	4.8	5.5	5.4	5.0	4.0	3.0	1.7	1.6	4.2
	Maximum	3.1	4.2	4.8	5.9	6.9	7.1	6.6	6.6	5.9	4.7	3.3	2.9	4.8
Lat°	Average	3.1	3.8	4.2	4.9	5.4	5.7	5.6	5.5	4.9	4.2	2.8	2.4	4.4
	Minimum	2.1	3.0	3.6	4.1	4.4	5.1	5.0	4.8	4.0	3.1	1.8	1.8	4.1
	Maximum	3.5	4.6	4.9	5.8	6.5	6.6	6.2	6.4	6.1	5.1	3.7	3.3	4.8
Lat + 15°	Average	3.3	3.9	4.1	4.5	4.8	4.9	4.9	5.0	4.7	4.2	2.9	2.6	4.1
	Minimum	2.2	3.0	3.5	3.8	4.0	4.4	4.3	4.3	3.8	3.1	1.8	1.8	3.8
	Maximum	3.8	4.7	4.9	5.4	5.7	5.7	5.4	5.8	5.8	5.2	3.8	3.6	4.5
90°	Average	3.1	3.5	3.2	3.0	2.8	2.6	2.7	3.1	3.4	3.4	2.5	2.4	3.0
	Minimum	2.0	2.5	2.7	2.5	2.4	2.5	2.5	2.8	2.7	2.5	1.5	1.7	2.7
	Maximum	3.7	4.3	3.8	3.6	3.2	3.0	2.9	3.5	4.2	4.3	3.5	3.5	3.3

SOLAR RADIATION FOR 1-AXIS TRACKING FLAT-PLATE COLLECTORS WITH A NORTH-SOUTH AXIS*

Axis Tilt		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0°	Average	2.5	3.5	4.5	5.9	7.3	8.0	7.9	7.0	5.6	4.1	2.4	1.9	5.1
	Minimum	1.7	2.7	3.9	4.7	5.8	7.1	6.9	5.9	4.4	3.0	1.6	1.5	4.7
	Maximum	2.9	4.2	5.4	7.3	9.1	9.6	8.9	8.5	6.9	5.0	3.0	2.6	5.7
Lat – 15°	Average	3.2	4.2	5.0	6.2	7.4	8.0	7.9	7.3	6.2	4.8	2.9	2.5	5.5
	Minimum	2.2	3.2	4.3	5.0	5.9	7.1	6.9	6.1	4.8	3.5	1.8	1.8	5.1
	Maximum	3.7	5.2	6.1	7.8	9.4	9.6	9.0	9.0	7.7	6.0	3.9	3.4	6.2
Lat°	Average	3.5	4.5	5.1	6.1	7.2	7.7	7.7	7.2	6.2	5.0	3.1	2.7	5.5
	Minimum	2.3	3.3	4.3	4.9	5.7	6.8	6.7	6.0	4.8	3.6	1.9	1.9	5.1
	Maximum	4.1	5.5	6.2	7.8	9.1	9.2	8.7	8.8	7.8	6.3	4.2	3.8	6.2
Lat + 15°	Average	3.7	4.5	5.0	5.9	6.8	7.2	7.2	6.8	6.0	5.0	3.2	2.9	5.3
	Minimum	2.4	3.3	4.2	4.6	5.4	6.3	6.2	5.7	4.6	3.5	1.9	2.0	4.9
	Maximum	4.3	5.6	6.1	7.4	8.6	8.6	8.1	8.4	7.6	6.3	4.4	4.1	6.0

SOLAR RADIATION FOR 2-AXIS TRACKING FLAT-PLATE COLLECTORS*

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
2-Axis Tracking	Average	3.7	4.6	5.1	6.2	7.5	8.2	8.1	7.4	6.2	5.0	3.2	2.9	5.7
	Minimum	2.4	3.4	4.3	5.0	6.0	7.2	7.1	6.2	4.8	3.6	1.9	2.0	5.2
	Maximum	4.3	5.6	6.2	7.8	9.5	9.8	9.2	9.0	7.8	6.3	4.4	4.1	6.4

DIRECT BEAM SOLAR RADIATION FOR CONCENTRATING COLLECTORS*

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1-Axis (E-W) Tracking	Average	2.0	2.2	2.2	2.6	3.3	3.7	3.6	3.3	2.9	2.6	1.7	1.5	2.6
	Minimum	1.1	1.3	1.6	1.8	2.1	3.0	2.8	2.3	1.9	1.5	0.7	0.9	2.3
	Maximum	2.5	3.3	3.1	3.8	4.9	4.9	4.4	4.4	4.1	3.6	2.6	2.5	3.2
1-Axis (N-S) Tracking, Tilt = 0°	Average	1.3	1.9	2.4	3.3	4.3	4.8	4.8	4.2	3.4	2.5	1.3	1.0	2.9
	Minimum	0.7	1.1	1.6	2.2	2.8	4.0	3.8	3.0	2.2	1.4	0.5	0.6	2.6
	Maximum	1.7	2.8	3.4	4.8	6.4	6.4	5.9	5.9	4.7	3.5	1.9	1.6	3.6
1-Axis (N-S) Tracking, Tilt = Lat°	Average	2.1	2.6	2.9	3.6	4.3	4.6	4.6	4.3	3.9	3.2	1.9	1.6	3.3
	Minimum	1.2	1.5	2.0	2.4	2.8	3.7	3.7	3.1	2.5	1.9	0.8	0.9	2.9
	Maximum	2.7	3.9	4.1	5.2	6.3	6.1	5.6	6.1	5.4	4.5	2.9	2.6	4.0
2-Axis Tracking	Average	2.3	2.7	2.9	3.6	4.5	5.0	4.9	4.5	3.9	3.3	2.0	1.7	3.4
	Minimum	1.3	1.6	2.0	2.4	3.0	4.1	3.9	3.2	2.5	1.9	0.8	1.0	3.0
	Maximum	2.9	4.0	4.1	5.2	6.7	6.6	6.1	6.2	5.4	4.5	3.0	2.8	4.2

AVERAGE CLIMATIC CONDITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Average Temperature (°C)	-6.1	-3.7	2.9	9.2	14.9	20.3	22.9	22.1	18.0	11.6	4.4	-3.0	9.4	
Average Low (°C)	-10.6	-8.2	-1.9	3.7	8.7	14.2	17.0	16.4	12.2	5.7	-0.2	-7.2	4.2	
Average High (°C)	-1.7	0.8	7.7	14.8	21.2	26.4	28.7	27.7	23.8	17.4	9.1	1.1	14.8	
Record Low (°C)	-32.8	-27.2	-22.2	-13.9	-4.4	2.2	4.4	5.0	-2.2	-8.3	-17.2	-31.7	-32.8	-27 Deg-F
Record High (°C)	18.3	21.7	31.1	32.8	33.9	40.0	38.9	38.3	37.2	32.8	25.6	21.7	40.0	104 Deg.F
Heating Degree Days†	758	616	479	273	131	19	3	11	47	217	417	661	3631	
Cooling Degree Days†	0	0	0	0	26	79	144	126	37	7	0	0	418	
Relative Humidity (%)	72	72	70	65	64	66	68	71	71	69	73	76	70	
Wind Speed (m/s)	5.2	5.1	5.4	5.3	4.6	4.2	3.7	3.6	4.0	4.5	4.8	4.9	4.6	

* in kWh/m²/day, ±9%
† based on 18.3°C (65°F)

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Appendix A

PV Module Space Calculation

Flat Roofs

MERRICK®
BUILDING QUALITY SOLUTIONS

Engineering Calculation Sheet

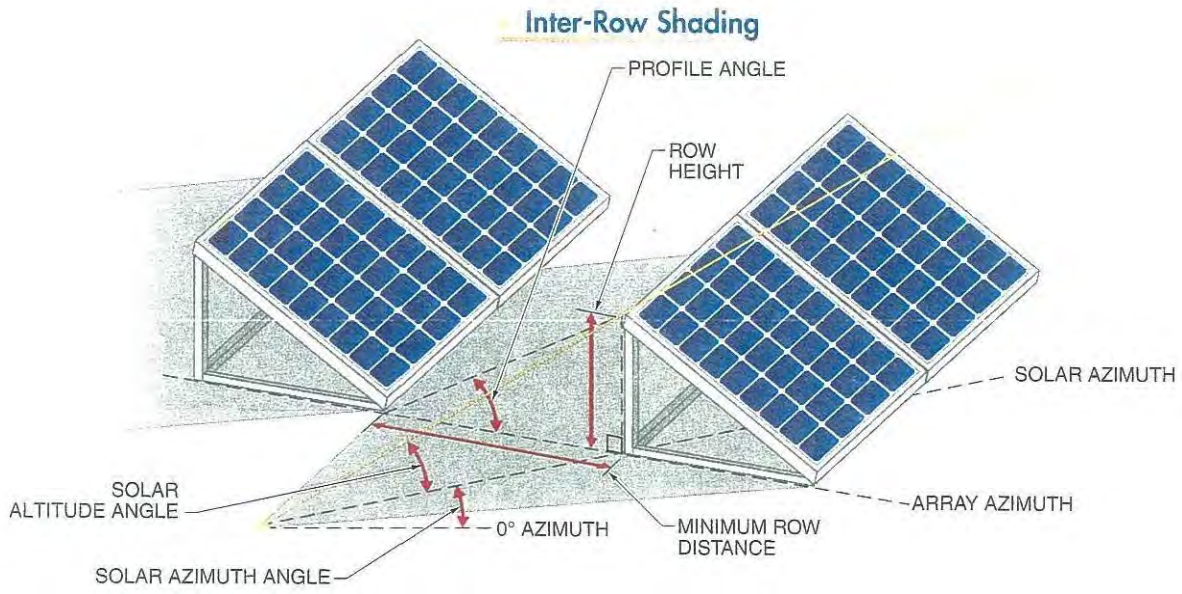
Date: 04/25/2014 By: ROT
Contract: 62018326
Calculation No.: 8326-Chicago

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Chicago

The purpose of this calculation is to determine the minimum distance separation between modules when placed in rows. Treating a row as a shading obstruction to the row behind it, the following formula will calculate the minimum distance between rows to avoid shading.

$$d = p \times (\cos(\psi - \mu)/\tan\alpha)$$

Where
d=minimum row separation distance (in ft)
p=row height (in)
ψ=azimuth angle per time of day
α=solar altitude angle (in deg)
μ=PV module azimuth from south reference



The rows must be spaced to avoid shading between 9AM and 3PM during the winter solstice. The orientation of the module out side of azimuth south, will impact the module spacing. The array azimuth and solar south azimuth will need to be added for both time references to determine worst case scenario for panel spacing,

MERRICK®
BUILDING QUALITY SOLUTIONS

Engineering Calculation Sheet

Date: 04/25/2014 By: ROT
Contract: 62018326
Calculation No.: 8326-Chicago

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Chicago

Calculate Panel Height on flat roof

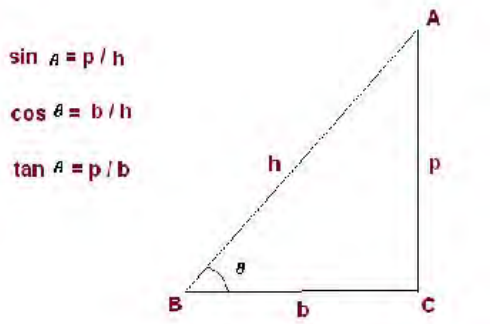
Solarworld Panel Module dimensions 39.41" x 65.94"

$\theta := 10deg$ Tilt Angle

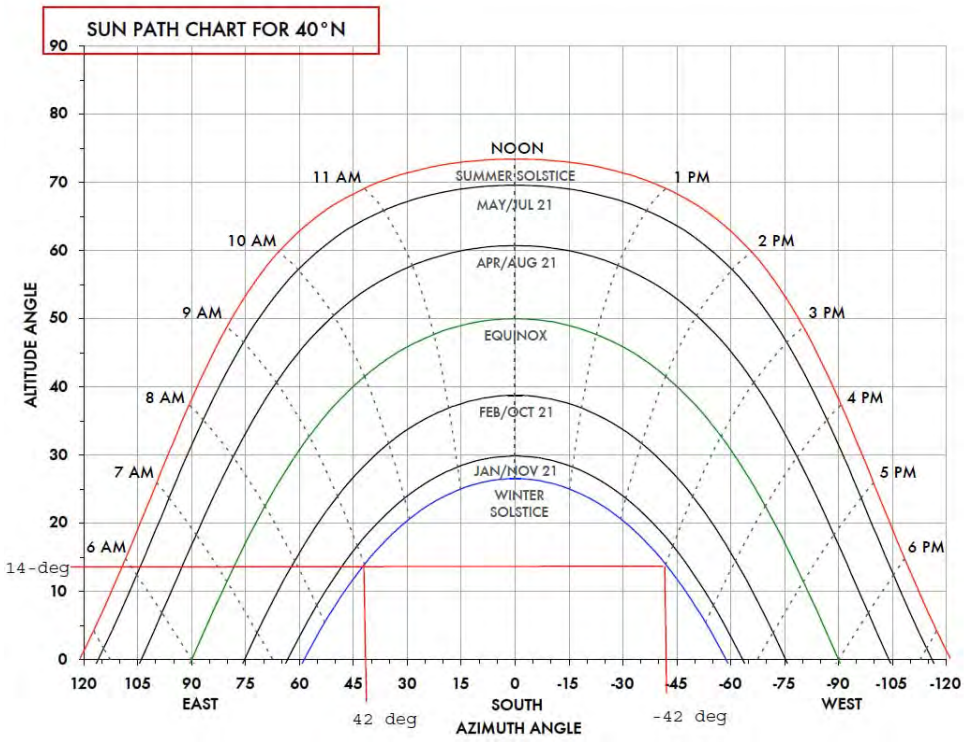
$h := 39.41in$ Tilt Length of PV module (h)

$p := h \cdot \sin(\theta)$ Panel Height from top of roof (p)=

$p = 6.84 \cdot in$



Calculate Solar Azimuth and Solar Altitude from Sun Path Chart



The 40-deg N Sun path indicates the Solar Altitude Angle is 14-deg at 9:00 AM and 3:00 PM. The South azimuth angle is 42-deg and 9:00 AM and -42-deg and 3:00 PM.

MERRICK®
BUILDING QUALITY SOLUTIONS

Engineering Calculation Sheet

Date: 04/25/2014 By: ROT
Contract: 62018326
Calculation No.: 8326-Chicago

Subject
Marine Corps Reserve Training Center
PV Module Row Space Calculation
Chicago

d= p x (cos(ψ-μ)/tanα)

Where
d=minimum row separation distance (in ft)
p=row height (in)
ψ=azimuth angle per time of day (9:00am) & (3:PM)
α=solar altitude angle (in deg)
μ=PV module azimuth from due south

$\psi_{.9am} := 42deg$ Azimuth angle of the sun from due South at 9:00 AM

$\psi_{3pm} := -42deg$ Azimuth angle of the sun from due South at 3:00 PM

$p = 6.84 \cdot in$

$\mu := -13deg$

$\alpha := 14deg$

$$d_{9am} := p \cdot \frac{\cos(\psi_{.9am} + \mu)}{\tan(\alpha)}$$

$d_{9am} = 24.01 \cdot in$

$$d_{3pm} := p \cdot \frac{\cos(\psi_{3pm} + \mu)}{\tan(\alpha)}$$

$d_{3pm} = 15.74 \cdot in$

$d_{max} := \max(d_{9am}, d_{3pm})$

$d_{max} = 2.00\,ft$ Worst case distance

Appendix B

Catalog Cut Sheets

Sunmodule® Plus SW 275 mono

TUV Power controlled:
Lowest measuring tolerance in industry

Every component is tested to meet
3 times IEC requirements

Designed to withstand heavy
accumulations of snow and ice

Sunmodule Plus:
Positive performance tolerance

25-year linear performance warranty and
10-year product warranty

World-class quality
Fully-automated production lines and seamless monitoring of the process and material ensure the quality that the company sets as its benchmark for its sites worldwide.

SolarWorld Plus-Sorting
Plus-Sorting guarantees highest system efficiency. SolarWorld only delivers modules that have greater than or equal to the nameplate rated power.

25 years linear performance guarantee and extension of product warranty to 10 years
SolarWorld guarantees a maximum performance degression of 0.7% p.a. in the course of 25 years, a significant added value compared to the two-phase warranties common in the industry. In addition, SolarWorld is offering a product warranty, which has been extended to 10 years.*

*in accordance with the applicable SolarWorld Limited Warranty at purchase.
www.solarworld.com/warranty

MADE IN USA

UL 1703

ISO 9001
ISO 14001
Certified

solarworld.com

We turn sunlight into power.

Sunmodule® Plus SW 275 mono

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

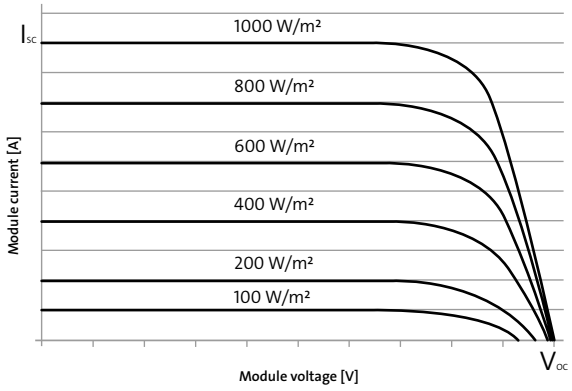
Maximum power	P_{max}	275 Wp
Open circuit voltage	V_{oc}	39.4 V
Maximum power point voltage	V_{mpp}	31.0 V
Short circuit current	I_{sc}	9.58 A
Maximum power point current	I_{mpp}	8.94 A

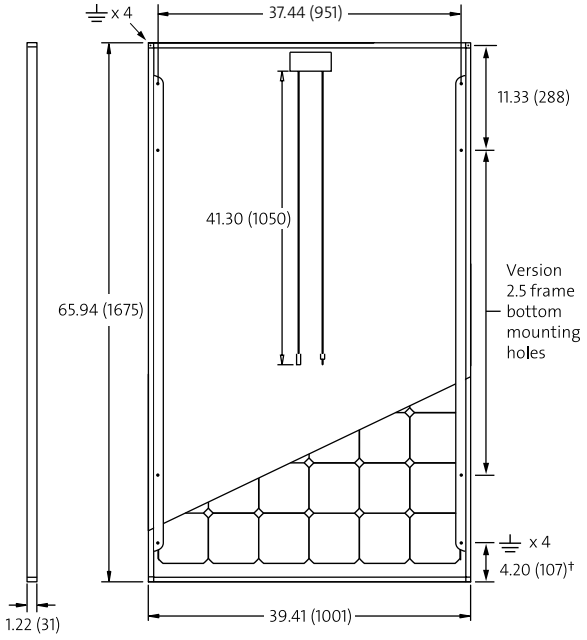
*STC: 1000 W/m², 25°C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled).

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.004 %/K
TC V_{oc}	-0.30 %/K
TC P_{mpp}	-0.45 %/K
Operating temperature	-40°C to 85°C





PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	205.0 Wp
Open circuit voltage	V_{oc}	36.1 V
Maximum power point voltage	V_{mpp}	28.4 V
Short circuit current	I_{sc}	7.75 A
Maximum power point current	I_{mpp}	7.22 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	60
Cell type	Mono crystalline
Cell dimensions	6.14 in x 6.14 in (156 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	46.7 lbs (21.2 kg)

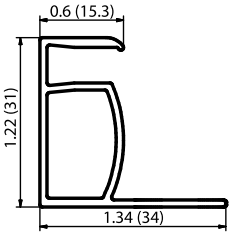
SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II		1000 V
Max. system voltage USA NEC		600 V
Maximum reverse current		16 A
Number of bypass diodes		3
UL Design Loads*	***Two rail system***	113 psf downward 64 psf upward
UL Design Loads*	***Three rail system***	170 psf downward 64 psf upward
IEC Design Loads*	***Two rail system***	113 psf downward 50 psf upward

* Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting[1]	-0 Wp / +5 Wp
J-Box	IP65
Connector	MC4
Module efficiency	16.40 %
Fire rating (UL 790)	Class C



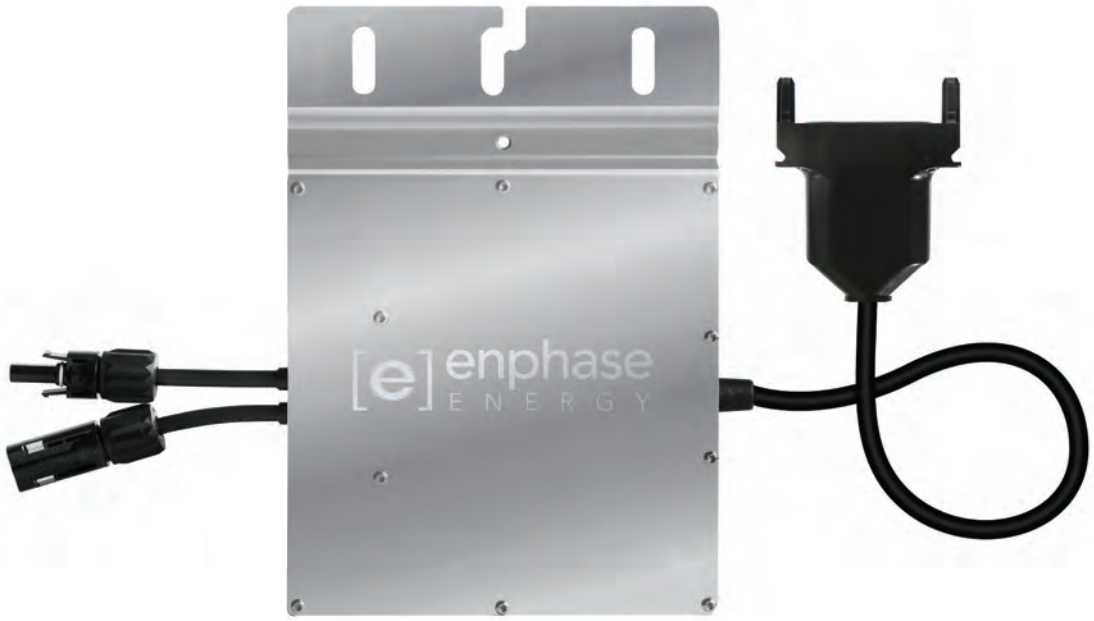
VERSION 2.5 FRAME

- Compatible with both "Top-Down" and "Bottom" mounting methods
- ⏚ Grounding Locations:
  - 4 corners of the frame
  - 4 locations along the length of the module in the extended flange†

NEW!

Independently created PAN files now available.
Ask your account manager for more information.

Enphase® **M250**



The **Enphase® M250 Microinverter** delivers increased energy harvest and reduces design and installation complexity with its all-AC approach. With the M250, the DC circuit is isolated and insulated from ground, so **no Ground Electrode Conductor (GEC) is required for the microinverter.** This further simplifies installation, enhances safety, and saves on labor and materials costs.

The Enphase M250 integrates seamlessly with the Engage® Cable, the Envoy® Communications Gateway™, and Enlighten®, Enphase's monitoring and analysis software.

PRODUCTIVE

- Optimized for higher-power modules
- Maximizes energy production
- Minimizes impact of shading, dust, and debris

SIMPLE

- No GEC needed for microinverter
- No DC design or string calculation required
- Easy installation with Engage Cable

RELIABLE

- 4th-generation product
- More than 1 million hours of testing and 3 million units shipped
- Industry-leading warranty, up to 25 years

INPUT DATA (DC)	**M250-60-2LL-S22/S23/S24**	
Recommended input power (STC)	210 - 300 W	
Maximum input DC voltage	48 V	
Peak power tracking voltage	27 V - 39 V	
Operating range	16 V - 48 V	
Min/Max start voltage	22 V / 48 V	
Max DC short circuit current	15 A	
Max input current	9.8 A	
OUTPUT DATA (AC)	**@208 VAC**	**@240 VAC**
Peak output power	250 W	250 W
Rated (continuous) output power	240 W	240 W
Nominal output current	1.15 A (A rms at nominal duration)	1.0 A (A rms at nominal duration)
Nominal voltage/range	208 V / 183-229 V	240 V / 211-264 V
Nominal frequency/range	60.0 / 57-61 Hz	60.0 / 57-61 Hz
Extended frequency range*	57-62.5 Hz	57-62.5 Hz
Power factor	>0.95	>0.95
Maximum units per 20 A branch circuit	24 (three phase)	16 (single phase)
Maximum output fault current	850 mA rms for 6 cycles	850 mA rms for 6 cycles
EFFICIENCY		
CEC weighted efficiency, 240 VAC	96.5%	
CEC weighted efficiency, 208 VAC	96.0%	
Peak inverter efficiency	96.5%	
Static MPPT efficiency (weighted, reference EN50530)	99.4 %	
Night time power consumption	65 mW max	
MECHANICAL DATA		
Ambient temperature range	-40°C to +65°C	
Operating temperature range (internal)	-40°C to +85°C	
Dimensions (WxHxD)	171 mm x 173 mm x 30 mm (without mounting bracket)	
Weight	2.0 kg	
Cooling	Natural convection - No fans	
Enclosure environmental rating	Outdoor - NEMA 6	
FEATURES		
Compatibility	Compatible with 60-cell PV modules.	
Communication	Power line	
Integrated ground	The DC circuit meets the requirements for ungrounded PV arrays in NEC 690.35. Equipment ground is provided in the Engage Cable. No additional GEC or ground is required.	
Monitoring	Free lifetime monitoring via Enlighten software	
Compliance	UL1741/IEEE1547, FCC Part 15 Class B, CAN/CSA-C22.2 NO. 0-M91, 0.4-04, and 107.1-01	

* Frequency ranges can be extended beyond nominal if required by the utility

To learn more about Enphase Microinverter technology, visit **enphase.com**

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Appendix C

Payback Calculation

SunEarthTools.com

Tools for consumers and designers of solar

19:21 | Tuesday 29 July 2014

Donate

Home
Photovoltaic payback
Sun Position
CO2 Emissions
Unit of measure converter
Full interactive map
Measure on Map
Distance
Coordinates conversion
SunRise SunSet Calendar
Photovoltaic FAQ
Build a sundial

Select Solar New Mexico
selectsolarpower.com
Start saving with solar today. Solar power is ready, come join in!

Photovoltaic payback

Economic analysis of a photovoltaic system, with the determination of payback and chart.
Enter data of the photovoltaic energy, then the data estimated cost of the plant, then Data eletrica bill.
Verifying the results of operations in the graph and table. Repeat the data entry when you have more accurate and definitive.

System PV		Own consumption energy	
Peak power Wp	88000	Own consumption kWh/y	89052
Energy production KWh/y	89052	Cost €/kWh	.09
Decay module PV %	0.70	Own consumption €	8015
Costs		**Contribution**	
Initial cost €	457600	Contribution €/kWh	
Cost €/KWp	5200	initial contribution €	0
Annual cost €	100	Annual contribution €	0
Final cost of disposal €	0		
Analysis period		**Bank financing**	
Years contributions	0	Mutual interests %	0.00
Years economic analysis	70	Annual loan installment €	0
Result			
Pay back [years | months]	[57 | 10]		
YTD Return (0 years)	0.30%	Cash balance (0 years)	-457600
Compound interest (0 years)	0.27%	Cash balance (70 years)	96428

execute

Albuquerque Solar experts
positiveenergysolar....
Ask us how PNM will pay you. Get SunPower. More Energy. For Life

Renewable Energy Courses
stanford.edu/energy
New Stanford certificate in Energy Innovation and Emerging Technology.

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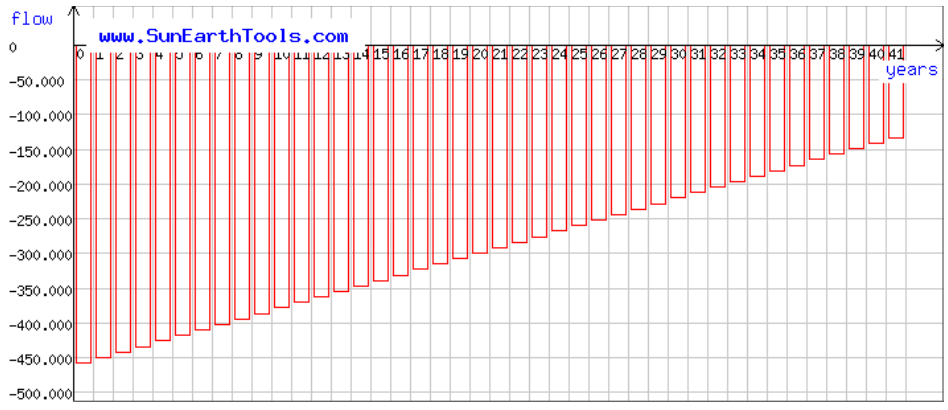

Back to top Content Data Chart Table

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Warning: number_format() expects parameter 1 to be double, string given in **/home/mhd-01/www.sunearthtools.com/htdocs/dp/utility/ajaxDP.php** on line **725**

year	flow	revenue		Prod.	Bill	Cost	Loan	YTD

Visits:
on Line:
p:1

0	-457.600	0		0	0	0	0	0.00 %
1	-449.685	7.915		0	8.015	-100	0	-98.27 %
2	-441.771	15.829		0	16.029	-200	0	-48.27 %
3	-433.856	23.744		0	24.044	-300	0	-31.60 %
4	-425.941	31.659		0	32.059	-400	0	-23.27 %
5	-418.027	39.573		0	40.073	-500	0	-18.27 %
6	-410.112	47.488		0	48.088	-600	0	-14.94 %
7	-402.197	55.403		0	56.103	-700	0	-12.56 %
8	-394.283	63.317		0	64.117	-800	0	-10.77 %
9	-386.368	71.232		0	72.132	-900	0	-9.38 %
10	-378.453	79.147		0	80.147	-1.000	0	-8.27 %
11	-370.539	87.061		0	88.161	-1.100	0	-7.36 %
12	-362.624	94.976		0	96.176	-1.200	0	-6.60 %
13	-354.709	102.891		0	104.191	-1.300	0	-5.96 %
14	-346.794	110.806		0	112.206	-1.400	0	-5.41 %
15	-338.880	118.720		0	120.220	-1.500	0	-4.94 %
16	-330.965	126.635		0	128.235	-1.600	0	-4.52 %
17	-323.050	134.550		0	136.250	-1.700	0	-4.15 %
18	-315.136	142.464		0	144.264	-1.800	0	-3.83 %
19	-307.221	150.379		0	152.279	-1.900	0	-3.53 %
20	-299.306	158.294		0	160.294	-2.000	0	-3.27 %
21	-291.392	166.208		0	168.308	-2.100	0	-3.03 %
22	-283.477	174.123		0	176.323	-2.200	0	-2.82 %
23	-275.562	182.038		0	184.338	-2.300	0	-2.62 %
24	-267.648	189.952		0	192.352	-2.400	0	-2.44 %
25	-259.733	197.867		0	200.367	-2.500	0	-2.27 %
26	-251.818	205.782		0	208.382	-2.600	0	-2.12 %
27	-243.904	213.696		0	216.396	-2.700	0	-1.97 %
28	-235.989	221.611		0	224.411	-2.800	0	-1.84 %
29	-228.074	229.526		0	232.426	-2.900	0	-1.72 %
30	-220.160	237.440		0	240.440	-3.000	0	-1.60 %
31	-212.245	245.355		0	248.455	-3.100	0	-1.50 %
32	-204.330	253.270		0	256.470	-3.200	0	-1.40 %
33	-196.416	261.184		0	264.484	-3.300	0	-1.30 %
34	-188.501	269.099		0	272.499	-3.400	0	-1.21 %
35	-180.586	277.014		0	280.514	-3.500	0	-1.13 %
36	-172.672	284.928		0	288.528	-3.600	0	-1.05 %
37	-164.757	292.843		0	296.543	-3.700	0	-0.97 %
38	-156.842	300.758		0	304.558	-3.800	0	-0.90 %
39	-148.927	308.673		0	312.573	-3.900	0	-0.83 %
40	-141.013	316.587		0	320.587	-4.000	0	-0.77 %
41	-133.098	324.502		0	328.602	-4.100	0	-0.71 %
42	-125.183	332.417		0	336.617	-4.200	0	-0.65 %
43	-117.269	340.331		0	344.631	-4.300	0	-0.60 %
44	-109.354	348.246		0	352.646	-4.400	0	-0.54 %
45	-101.439	356.161		0	360.661	-4.500	0	-0.49 %
46	-93.525	364.075		0	368.675	-4.600	0	-0.44 %
47	-85.610	371.990		0	376.690	-4.700	0	-0.40 %
48	-77.695	379.905		0	384.705	-4.800	0	-0.35 %
49	-69.781	387.819		0	392.719	-4.900	0	-0.31 %
50	-61.866	395.734		0	400.734	-5.000	0	-0.27 %
51	-53.951	403.649		0	408.749	-5.100	0	-0.23 %
52	-46.037	411.563		0	416.763	-5.200	0	-0.19 %
53	-38.122	419.478		0	424.778	-5.300	0	-0.16 %
54	-30.207	427.393		0	432.793	-5.400	0	-0.12 %
55	-22.293	435.307		0	440.807	-5.500	0	-0.09 %
56	-14.378	443.222		0	448.822	-5.600	0	-0.06 %
57	-6.463	451.137		0	456.837	-5.700	0	-0.02 %
58	1.451	459.051		0	464.851	-5.800	0	0.01 %
59	9.366	466.966		0	472.866	-5.900	0	0.03 %

60	17.281	474.881		0	480.881	-6.000	0	0.06 %
61	25.195	482.795		0	488.895	-6.100	0	0.09 %
62	33.110	490.710		0	496.910	-6.200	0	0.12 %
63	41.025	498.625		0	504.925	-6.300	0	0.14 %
64	48.940	506.540		0	512.940	-6.400	0	0.17 %
65	56.854	514.454		0	520.954	-6.500	0	0.19 %
66	64.769	522.369		0	528.969	-6.600	0	0.21 %
67	72.684	530.284		0	536.984	-6.700	0	0.24 %
68	80.598	538.198		0	544.998	-6.800	0	0.26 %
69	88.513	546.113		0	553.013	-6.900	0	0.28 %
70	96.428	554.028		0	561.028	-7.000	0	0.30 %

Back to top Content Data Chart Table

Content

Initial cost, Cost€/KWp

Annual cost

Peak power Wp

Energy production KWh/y

Contribution €/kWh

initial contribution, Annual contribution

Consumption kWh/y, Own consumption kWh/y

Cost €/kWh

Years contributions, Years economic analysis

Decay module PV %

Mutual interests %, Annual loan installment

Result

Comment

Back to top Content Data Chart Table

Initial cost, Cost€/KWp

Represents the value of the initial investment, then the cost of the turnkey.
This information should be provided by an estimate of a designer, because the value is affected by many factors (eg: cost of natural building, plant engineering, integration, bureaucratic, etc.)that only after a careful evaluation may provide a precise value.
To give a rough idea, we could say that the average value is around 6000 €/kWp.
This value should take into consideration the cost of replacing the inverter which has an average lifespan of 12-15 years and costs about 5-8% of the value of the plant.

Back to top Content Data Chart Table

Annual cost

Represents the sum of all costs such as electric charge of the operator, maintenance, cleaning, insurance, etc.

Back to top Content Data Chart Table

Peak power Wp

The nominal power in kWp of a photovoltaic system is given by the sum of the peak of the modules used,
this value is declared by the manufacturer and is measured in standard conditions, with irradiation constant 1kW per square meter in the plane of the panel, at a temperature (modul) of 25°C.

Back to top Content Data Chart Table

Energy production KWh/y

The output of energy in a year (kWh/y), the correct value is the extent made by the electricity meter (after one year of operation).
An estimate may be made known: the maximum power rating, the angle of inclination of PV modules from a horizontal plane, the angle of orientation of PV modules by the south, and the coefficient of performance, which represents the fraction of the power supplied by panel which will be introduced into the power grid. The difference is caused by losses in the cables and inverter, but also from reduced performance due to temperature effects. For a facility with a PV inverter efficiency can reach a value of 0.8 (total reduction of 20%). For small systems or systems with a match modules/inverter less optimal can still expect a value from 0.7 to 0.75.

Back to top Content Data Chart Table

Contribution €/kWh

Contribution €/kWh

Back to top Content Data Chart Table

initial contribution, Annual contribution

The contribution is a part that is paid from grants from municipalities, regions or nations that seek to fund the dissemination of photovoltaic energy. This contribution can be in a single installment or in annual installments.

Back to top Content Data Chart Table

Consumption kWh/y, Own consumption kWh/y

The annual energy consumption in kWh/y, is the amount of energy transferred from the distributor last year, can be derived by consulting the current bill and the previous year.

Back to top Content Data Chart Table

Cost €/kWh

Represents the average cost for KWh of electricity charged by the operator, can be calculated by dividing the annual expenditure on consumption of energy for energy consumption for the same year.

Back to top Content Data Chart Table

Years contributions, Years economic analysis

Years contributions represents the period in which the owner of the photovoltaic system will have a contribution to the energy produced, while the years of analysis represents the total period over which economic analysis is made.

Back to top Content Data Chart Table

Decay module PV %

The decay of the photovoltaic system did not yield a clear trend, in the first 2 years of the decade at most 2-3%, for the next 8 years maximum of 0.7% and then a maximum of 0.5%.
There are other factors that affect these values, first of all the material of photovoltaic panels, the monocrystalline silicon has lower values (about 0.1%) over the polysilicon, which in turn has lower values than the amorphous panels. Other factors are: the weather, the installation site, and type of installation.
The average life of a good solar cell is guaranteed for at least 25 years (with a decline below 80%), but can reach over 40 years.
The average values of decay ranging from 0.6% to a maximum of 1.1%, of course should be assessed all the factors that shaped him.

Back to top Content Data Chart Table

Mutual interests %, Annual loan installment

If you choose a loan or mortgage, for the purchase of the plant is necessary to include the interest of the funding.
The annual installment will be calculated assuming that the funding will last throughout the period of the incentives and covering the full amount of the plant.

Back to top Content Data Chart Table

Result

Back to the time required to recover the initial investment (taking into consideration of all the annual expenses) is expressed in years and months.
The return on investment as interest is calculated using the expression of interest seplice:
interest = (Final capital - initial investment) / initial investment / years of analysis * 100
and a compound, which is the constant interest of an investment each year and is capitalized at the end of the period of analysis returns the same Final capital.

Back to top Content Data Chart Table

Comment

If you detect a bug or other inaccuracy, want to suggest a new feature or simply want to express an opinion about the site, feel free to do in the "Comment" section that follows. The site administrators appreciate all comments as we strive to produce an accurate and constructive resource.
Thanks in advance for your contribution to improve this site (please correct the errors of grammar and translation).

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Validation code (required)

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Back to top Content Data Chart Table

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Appendix E – Electrical Calculations and Cut Sheets

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MERRICK & COMPANY

Engineering Calculation Sheet

Date	7/30/2014	Sheet	1	of	1
Contract					
By	staff	Chk'd	staff		

Subject:	Solar PV Systems MARFORRES
	Chicago, IL
	Lightning Protection Risk Assessment
	Reserve Center - Northeast

Revision	By	Date	Chk'd	Date

LIGHTNING PROTECTION RISK ASSESSMENT CALCULATION

Per NFPA 780, 2011 Edition, Annex **L**, Lightning Risk Assessment, the tolerable lightning strike frequency (Nc) is compared with the expected lightning frequency (Nd). The result of this comparison is used to decide if a lightning protection system is needed. If Nd≤Nc, a lightning protection system can be optional. If Nd>Nc, a lightning protection system should be provided.

LIGHTNING STRIKE FREQUENCY (N_d)

$N_d = (N_g)(A_e)(C_1)(10^{-6})$

N_d = the yearly lightning strike frequency to the structure

N_g = the yearly average flash density in the region

A_e = the equivalent collective area of the structure (m^2)

C_1 = the environmental coefficient

N_g = 5 flashes/sq km/yr based on Vaisala Flash Density Map, Figure L.2 (a) or (b) in NFPA 780

$A_e = LW+6H(L+W)+\pi(9)(H^2)$ = 1883.4 m^2

H_2 =	0.0	ft	0	m	height of low roof
H_1 =	11.5	ft	4	m	height of high roof
L =	113.0	ft	34	m	overall building length
W =	48.0	ft	15	m	overall building width

C_1 = .25 Structure surrounded by larger structures or trees within distance of 3H

N_d = 0.0024

TOLERABLE LIGHTNING FREQUENCY (N_c)

$N_c = 1.5x10^{-3}/C$

$C = (C_2)(C_3)(C_4)(C_5)$

C_2 =	1.0	Nonmetallic structure, nonmetallic roof
C_3 =	1.0	Standard value and nonflammable
C_4 =	1.0	Normally occupied
C_5 =	1.0	Continuity of facility service not required, no environmental impact
C =	1.0	

N_c = 0.0015

0.0024	**>**	**0.0015**	**A lightning protection system should be installed**
N_d	**>**	**Nc**	

No existing lightning prot. system

Type PRL3a

Contents

Description	*Page*
Product Description	**V2-T3-7**
Application Description	**V2-T3-8**
Standards and Certifications	**V2-T3-10**
Technical Data and Specifications	**V2-T3-11**
Type PRL1a	**V2-T3-26**
Type PRL1aF	**V2-T3-30**
Type PRL1a-LX	**V2-T3-34**
Type PRL2a	**V2-T3-38**
Type PRL2aF	**V2-T3-42**
Type PRL2a-LX	**V2-T3-46**
Retrofit Panelboard	**V2-T3-50**
Type PRL3a	**V2-T3-58**
Product Selection	**V2-T3-59**
Box Sizing and Selection	**V2-T3-61**
Type PRL3E	**V2-T3-62**
Type PRL4	**V2-T3-66**
Type PRL4D	**V2-T3-76**
Type PRL5P	**V2-T3-86**

Type PRL3a

Product Description

- 600 Vac maximum (250 Vdc)
- Three-phase four-wire, three-phase three-wire, single-phase three-wire, single-phase two-wire
- 800A maximum main lugs
- 600A maximum main breaker
- 225A maximum branch breakers
- Bolt-on branch breakers
- Factory assembled
- Refer to **Page V2-T3-7** for additional information

Application Description

- Lighting panelboard or power distribution panelboard
- Fully rated or series rated
- Interrupting ratings up to 200 kA symmetrical
- Suitable for use as Service Entrance Equipment, when specified on the order
- See **Pages V2-T3-7** through **V2-T3-23** for additional information

Standards and Certifications

- UL 67, UL 50
- Federal Specification W-P-115c
- Refer to **Page V2-T3-7** for additional information

Listed

Product Selection

Type PRL3a

PRL3a

Ampere Rating	Interrupting Rating (kA Symmetrical) 240 Vac	480 Vac	600 Vac	250 Vdc	Breaker Type
Main Lug Only					
100	—	—	—	—	—
250	—	—	—	—	—
400	—	—	—	—	—
600	—	—	—	—	—
800 ①	—	—	—	—	—
Main Breaker					
100	18	14	—	10	EHD
100	18	14	14	10	FDB
100	22	—	—	—	EDB
100	42	—	—	—	EDS
100	65	—	—	—	ED
100	100	—	—	—	EDH
100	65	35	18	10	FD, FDE
100	100	65	25	22	HFD, HFDE
100	200	100	35	22	FDC
100	200	150	—	—	FCL
100	200	200	200	100 ②	FB-P ③
225	22	—	—	—	EDB
225	42	—	—	—	EDS
225	65	—	—	—	ED
225	100	—	—	—	EDH
225	200	—	—	—	EDC
225	65	35	18	10	FD, FDE
225	100	65	25	22	HFD, HFDE
225	200	100	35	22	FDC
250	65	35	18	10	JD
250	100	65	25	22	HJD
250	200	100	35	22	JDC
400	65	—	—	10	DK
400	65	35	25	10	KD
400	100	65	35	22	HKD
400	100	65	—	—	LHH
400	200	100	65	22	KDC
400	65	—	—	—	LCL ④
400	200	200	200	100 ②	LA-P ③④
600	65	35	18	22	LGE
600	100	65	35	22	LGH
600	200	100	50	42	LGC
600	65	35	25	22	LD
600	100	65	35	25	HLD
600	200	100	50	25	LDC
600	65	35	25	22	CLD ⑤
600	100	65	35	25	CHLD ⑤
600	200	100	50	25	CLDC ⑤

Notes

① 800A MLO requires 28-inch (711.2 mm) wide box.
② 100,000 based on NEMA test procedure.
③ Top feed only.
④ Requires 6.50-inch (165.1 mm) deep box. Not available in Type 3R, 12, 4 and 4X enclosures.
⑤ 100% rated circuit breaker. Requires copper bus. Not available in Type 12, 4 and 4X enclosures.

PRL3a Branch Circuit Breakers

Ampere Rating	Interrupting Rating (kA Symmetrical) 240 Vac	480 Vac	600 Vac	250 Vdc	Breaker Type
15–60	10 ②③	—	—	—	BAB
15–60	10	—	—	—	BAB-H
70	10 ②③	—	—	—	BAB
70	10	—	—	—	BAB-H
80–100	10 ②③	—	—	—	BAB
80–100	10	—	—	—	BAB-H
15–50 ①	10 ②③	—	—	—	QBGF
15–50 ①	10	—	—	—	QBGFEP
15–20	10 ②③	—	—	—	QBCAF ④
15–60	10 ②③	—	—	—	BAB-D ⑤
15–30	10 ②③	—	—	—	BAB-C ⑥
15–30	10 ②	—	—	—	BABRP ⑦
15–30	10 ②	—	—	—	BABRSP ⑦
15–60	22 ②③	—	—	—	QBHW
15–60	22	—	—	—	QBHW-H
70	22 ②③	—	—	—	QBHW
70	22	—	—	—	QBHW-H
80–100	22 ②③	—	—	—	QBHW
80–100	22	—	—	—	QBHW-H
15–30	22	—	—	—	QBHGF
15–30	22	—	—	—	QBHGFEP
15–20	22 ②③	—	—	—	QBHCAF ④
15–20	65	14 ⑧⑨	—	—	GHQ
15–20	65	14 ⑧⑨	—	14	GHB

PRL3a Branch Circuit Breakers, continued

Ampere Rating	Interrupting Rating (kA Symmetrical) 240 Vac	480 Vac	600 Vac	250 Vdc	Breaker Type
25–60	65	14 ⑧⑨	—	14	GHB
70–100	65	14 ⑧⑨	—	14	GHB
15–30	65	25 ⑧⑨	—	—	HGHB
15–20	65	14 ⑧⑨	—	14	GHQRSP ⑦
15–30	65	14 ⑧⑨	—	14	GHBS ⑦
15–60	—	14 ⑧⑨	—	—	GHBGFEP
15–20	—	14 ⑧⑨	—	—	GHBHID ⑤
15–60	18 ⑩	14 ⑧	—	10	EHD
70–100	18 ⑩	14 ⑧	—	10	EHD
15–60	18	V14	14	10	FDB
70–100	18	14	14	10	FDB
110–150	18	14	14	10	FDB
15–60	65 ⑩	35 ⑧	18	10	FD, FDE
70–100	65 ⑩	35 ⑧	18	10	FD, FDE
110–225	65 ⑩	35	18	10	FD ⑪, FDE
15–60	100 ⑩	65 ⑧	25	22	HFD, HFDE
70–100	100 ⑩	65 ⑧	25	22	HFD, HFDE
110–225	100 ⑩	65	25	22	HFD ⑪, HFDE
15–60	200	100	35	22	FDC
70–100	200	100	35	22	FDC
110–225	200	100	35	22	FDC ⑪
100–225	22	—	—	—	EDB ⑪
100–225	42	—	—	—	EDS ⑪
100–225	65	—	—	—	ED ⑪
100–225	100	—	—	—	EDH ⑪
100–225	200	—	—	—	EDC ⑪

Notes

① 50A devices are available as two-pole only.
② Single-pole breaker rated 120 Vac.
③ Two-pole breaker rated 120/240 Vac.
④ Arc fault circuit breaker.
⑤ HID (High Intensity Discharge) rated breaker.
⑥ Switching Neutral Breaker. single-pole device requires two-pole space, two-pole device requires three-pole space.
⑦ Solenoid operated breaker.
⑧ Single-pole breaker rated 277 Vac.
⑨ For use on 480Y/277V systems only.
⑩ AIC rating for two- and three-pole breakers only.
⑪ Maximum of six breakers per panel, 175–225A.

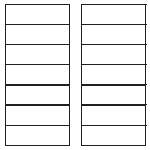
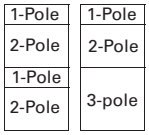
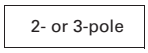
Box Sizing and Selection

Approximate Dimensions in Inches (mm)

Panel Layout Instructions

1. Select:
   a. Required mains (lugs or breaker).
   b. Neutral where required.
   c. Branch circuits as required.
2. Layout panel as shown below, using appropriate "X" dimensions.
3. Using total X units (panel height) find box height in inches (mm) and box catalog number from table below. (When total X units come out to an uneven number, use next highest number; i.e., if total X comes out 25X, use 31X.)

Layout—PRL3a

		Poles	
		6 - 3X 12 - 5X 18 - 8X 24 - 10X 30 - 13X 36 - 15X 42 - 18X	BAB, QBHW, QBCAF, BABRP, BABRSP, QBHCAF GHQ, GHB, HGHB ①
		1X 2X 3X	EDB, EDS, ED, EDH, EDC, EHD, FDB, FD, FDE, HFD, FDC, HFDE 150A max. per branch breaker (300A max. per connector)
		2X 2-Pole 3X three-pole	EDB, EDS, ED, EDH, EDC FD, HFD, FDC, ② FDE, HFDE
Neutral Section		5X 8X 11X	100–250A 400–800A 800A with through-feed lug
Main Lug Section		2X 5X 8X 14X	100A 250A 400–600A 800A
Main Breaker Section	Horizontal Mounting	2X 2-Pole 3X three-pole	EHD, FDB, FD, HFD, FDC, FDE, HFDE EDB, EDS, ED, EDH, EDC ③
	Vertical Mounting	7X 9X 14X 15X 17X 18X 21X	EHD, FDB, FD, FDE, HFD, FDC, HFDE, EDB, EDS, ED, EDH, EDC ④ FCL, FB-P ⑤ JD, HJD, JDC DK, KD, HKD, KDC, LHH LD, HLD, LDC, CLD, CHLD, CLDC LGE, LGH, LGC LCL, LA-P ⑤⑥

Notes

① GHB, HGHB and GHQ breakers cannot be mixed on same connector as BAB, QBHW, BABRP and BABRSP.
② Maximum of six breakers per panel.
③ Horizontal mounted 15–150A main breakers EHD, FDB, FD, FDE, HFD, HFDE and FDC, will be furnished as branch breaker construction. Branch breakers single-, two- or three-pole as required, may be located opposite these main breakers.
④ If optional terminal kit 3TA225FDK is required, use 10X.
⑤ FB-P and LA-P top mounting only.
⑥ LCL or LA-P main breaker requires 6-1/2-inch (165.1 mm) deep box.

Layout Example

1. Description of Panel
   Type PRL3a three-phase, four-wire, 120/208 Vac flush mounting. Panel to have short-circuit rating of 22,000 symmetrical amperes. Main breaker 400A, three-pole, bottom mounting. Branch circuits bolt-on as follows:
   12–200A single-pole QBHW
   1–200A three-pole ED
   1–225A three-pole ED
2. Layout Information from **Layout—PRL3a** table (left):
   a. 400A Neutral . . . . . = 8X
   b. 12-poles of QBHW . . . . . = 5X
   c. Two three-pole ED breakers . . = 6X
   d. Main breaker, 400A,
      Three-pole DK . . . . . = 15X
      Total Height . . . . . = 34X
3. From **Box Tabulation—PRL3a** table (below):
   a. 34X Height (use 40X box)
   b. Box Height 72 inches (1828.8 mm)
   c. Box Catalog Number . . . . . **YS2072** or **EZB2072R**

Box Tabulation—PRL3a

"X" Units	Box Height	YS Box Catalog Number	LT Trim Catalog Number	EZ Box Catalog Number	EZ Trim Catalog Number
100–400A					
14X	36.00 (914.4)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
23X	48.00 (1219.2)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
31X	60.00 (1524.0)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
40X	72.00 (1524.0)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
53X	90.00 (2286.0)	**YS2090**	**LT2090S or F**	**EZB2090R**	**EZT2090S or F**
600A					
23X	48.00 (1219.2)	**YS2048**	**LTV2048S or F**	**EZB2048R**	**EZTV2048S or F**
31X	60.00 (1524.0)	**YS2060**	**LTV2060S or F**	**EZB2060R**	**EZTV2060S or F**
40X	72.00 (1524.0)	**YS2072**	**LTV2072S or F**	**EZB2072R**	**EZTV2072S or F**
53X	90.00 (2286.0)	**YS2090**	**LTV2090S or F**	**EZB2090R**	**EZTV2090S or F**
800A					
23X	48.00 (1219.2)	**YS2848**	**LTV2848S or F**	—	—
31X	60.00 (1524.0)	**YS2860**	**LTV2860S or F**	—	—
40X	72.00 (1524.0)	**YS2872**	**LTV2872S or F**	—	—
53X	90.00 (2286.0)	**YS2890**	**LTV2890S or F**	—	—

Cabinets

Fronts are code-gauge steel, ANSI-61 light gray painted finish.

Boxes are code-gauge galvanized steel without knockouts. Standard depth is 5-3/4 inches (146.1 mm).

Standard widths are:
20-inch (508.0 mm)
100–600A.
28-inch (711.2 mm)
800A.

Standard Depth

5-3/4 inches (146.1 mm).

Top and Bottom Gutters

5-1/2 inches (139.7 mm) minimum.

Side Gutters

4 inches (101.6 mm) minimum.

Type PRL1a

Contents

Description	*Page*
Product Description	**V2-T3-7**
Application Description	**V2-T3-8**
Standards and Certifications	**V2-T3-10**
Technical Data and Specifications	**V2-T3-11**
Type PRL1a	
Product Selection	**V2-T3-27**
Box Sizing and Selection	**V2-T3-28**
Type PRL1aF	**V2-T3-30**
Type PRL1a-LX	**V2-T3-34**
Type PRL2a	**V2-T3-38**
Type PRL2aF	**V2-T3-42**
Type PRL2a-LX	**V2-T3-46**
Retrofit Panelboard	**V2-T3-50**
Type PRL3a	**V2-T3-58**
Type PRL4	**V2-T3-66**
Type PRL4D	**V2-T3-76**
Type PRL5P	**V2-T3-86**

Type PRL1a

Product Description

- 240 Vac maximum
- Three-phase four-wire, three-phase three-wire, single-phase three-wire, single-phase two-wire
- 400A maximum mains
- 100A maximum branch breakers
- Bolt-on or plug-on branch breakers
- Each branch connector is capable of up to a total of 140A maximum by breaker ampere rating
- Factory assembled
- Refer to **Page V2-T3-7** for additional information

Application Description

- Lighting branch panelboard
- Fully rated or series rated
- Interrupting ratings up to 200 kA symmetrical
- Suitable for use as Service Entrance Equipment, when specified on the order
- See **Pages V2-T3-7** through **V2-T3-23** for additional information

Standards and Certifications

- UL 67, UL 50
- Federal Specification W-P-115c
- Refer to **Page V2-T3-7** for additional information

UL Listed

Product Selection

Type PRL1a

PRL1a

Ampere Rating	Interrupting Rating (kA Sym.) 240 Vac	Breaker Type
Main Lug Only		
100	—	—
225	—	—
400	—	—
Main Breaker		
100	10	BAB
100	18	EHD
100	22	QBHW
100	22	EDB
100	42	EDS
100	65	ED
100	65	FD, FDE
100	100	EDH
100	100	HFD, HFDE
225	22	EDB
225	42	EDS
225	65	ED
225	100	EDH
250	65	JD
250	100	HJD
250	200	JDC
400	65	DK
400	65	KD
400	100	HKD
400	100	LHH
400	200	KDC

PRL1a Branch Circuit Breakers

Bolt-on = BAB, QBHW, QBGF, QBHGF, QBGFEP, QBHGFEP, QBAF, QBAG, QBHAF, QBHAG
Plug-on = HQP, QPHW, QPGF, QPHGF, QPGFEP, QPHGFEP

Ampere Rating	Interrupting Rating (kA Sym.) 240 Vac ①	Breaker Type
15–60	10	BAB, HQP
70	10	BAB, HQP
80–100	10	BAB, HQP
15–50 ②	10	QBGF, QPGF ③
15–50 ②	10	QBGFEP, QPGFEP ④
15–20	10	QBCAF ⑤
15–60	10	BAB-D, HQP-D ⑥
15–30	10	BAB-C, HQP-B ⑦
15–30	10	BABRP ⑧
15–30	10	BABRSP ⑧
15–60	22	QBHW, QPHW
70	22	QBHW, QPHW
80–100	22	QBHW, QPHW
15–30	22	QBHGF, QPHGF ③
15–30	22	QBHGFEP, QPHGFEP ④
15–20	22	QBHCAF ⑤
Provision	—	—

Notes

① Single-pole breakers are rated 120 Vac maximum.
② 50A devices are available as two-pole only.
③ GFCI for 5 mA personnel protection.
④ GFP for 30 mA equipment protection.
⑤ Arc fault circuit breaker.
⑥ HID (High Intensity Discharge) rated breaker.
⑦ Switching Neutral Breaker. single-pole device requires two-pole space, two-pole device requires three-pole space.
⑧ Solenoid operated breaker.

Box Sizing and Selection

Approximate Dimensions in Inches (mm)

Assembled Circuit Breaker Panelboards and Lighting Controls

Box size and box and trim catalog numbers for all standard panelboard types are found on **Page V2-T3-29**.

Instructions

1. Using description of the required panelboard, select the rating and type of main required.
2. Count the total number of branch circuit poles, including provisions, required in the panelboard. Do not count main breaker poles. Convert two- or three-pole branch breaker to single-poles, i.e., three-pole breaker, count as three poles. Determine sub-feed breaker or through-feed lug requirements.
3. Select the main ampere rating section from table on **Page V2-T3-29**.
4. Select panelboard type from first column, main breaker frame, if applicable, from second column, and sub-feed breaker frame, if applicable, from the third column.
5. From Step #2, determine the number of branch circuits in Column 4.
6. Read box size, box and trim catalog numbers across columns to the right. Specify surface or flush mounting on the order.

Cabinets

Fronts are code-gauge steel, ANSI-61 light gray painted finish.

Boxes are code-gauge galvanized steel without knockouts. Standard depth is 5-3/4 inches (146.1 mm). Standard width is 20 inches (508.0 mm). An optional 28-inch (711.2 mm) wide box is available.

Top and Bottom Gutters

5-1/2 inches (139.7 mm) minimum.

Approximate Dimensions in Inches (mm)

PRL1a Panelboard Sizing

Panelboard Types	Main Breaker Types and Mounting Position (H) = Horizontal (V) = Vertical	Sub-Feed Breaker Types and Mounting Position (H) = Horizontal (V) = Vertical	Maximum No. of Branch Circuits Including Provisions	Box Dimensions ① Height	Width	Depth	YS Box Catalog Number	LT Trim Catalog Number	EZ Box Catalog Number	EZ Trim Catalog Number
100A										
Main breaker	BAB, QBHW (H)	—	15	36.00 (914.4)	20.00 (508.0)	5.75 (146.1)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
		—	27	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	39	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
Main lugs or main breaker	EHD FD, HFD (V)	—	18	36.00 (914.4)	20.00 (508.0)	5.75 (146.1)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
		—	30	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	42	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
Main lugs or main breaker with 100A through-feed lugs or sub-feed breaker	EHD FD HFD (V)	EHD FD HFD (V)	18	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
			30	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
			42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
225A										
Main lugs or main breaker	EDB, EDS, ED, EDH, FD, HFD (V)	—	18	36.00 (914.4)	20.00 (508.0)	5.75 (146.1)	**YS2036**	**LT2036S or F**	**EZB2036R**	**EZT2036S or F**
		—	30	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	42	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
Main lugs or main breaker with 225A throughfeed lugs or sub-feed breaker	FD, HFD, EDS, ED, EDH (V)	FD, HFD, EDS, ED, EDH (V)	18	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
			30	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
			42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
400A										
Main breaker	DK, KD, HKD, KDC, LHH (V)	—	18	48.00 (1219.2)	20.00 (508.0)	5.75 (146.1)	**YS2048**	**LT2048S or F**	**EZB2048R**	**EZT2048S or F**
		—	30	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
		—	42	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
Main lugs or main breaker with 225A through-feed lugs or sub-feed breaker	DK, KD, HKD, KDC, LHH (V)	FD, HFD, EDS, ED, EDH (V)	18	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
			30	60.00 (1524.0)	20.00 (508.0)	5.75 (146.1)	**YS2060**	**LT2060S or F**	**EZB2060R**	**EZT2060S or F**
			42	72.00 (1828.8)	20.00 (508.0)	5.75 (146.1)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
Main breaker with 400A through-feed lugs or sub-feed breaker	DK, KD, HKD, KDC, LHH (V)	DK, KD, HKD, KDC (V)	18	72.00 (1828.8)	20.00 (508.0)	5.75 (146.1)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
			30	72.00 (1828.8)	20.00 (508.0)	5.75 (146.1)	**YS2072**	**LT2072S or F**	**EZB2072R**	**EZT2072S or F**
			42	90.00 (2286.0)	20.00 (508.0)	5.75 (146.1)	**YS2090**	**LT2090S or F**	**EZB2090R**	**EZT2090S or F**

Note

① Smaller panelboard box sizes are available if required. Contact Eaton for application information.

Sunmodule® Plus SW 275 mono

TUV Power controlled:
Lowest measuring tolerance in industry

Every component is tested to meet
3 times IEC requirements

Designed to withstand heavy
accumulations of snow and ice

Sunmodule Plus:
Positive performance tolerance

25-year linear performance warranty and
10-year product warranty

World-class quality
Fully-automated production lines and seamless monitoring of the process and material ensure the quality that the company sets as its benchmark for its sites worldwide.

SolarWorld Plus-Sorting
Plus-Sorting guarantees highest system efficiency. SolarWorld only delivers modules that have greater than or equal to the nameplate rated power.

25 years linear performance guarantee and extension of product warranty to 10 years
SolarWorld guarantees a maximum performance degression of 0.7% p.a. in the course of 25 years, a significant added value compared to the two-phase warranties common in the industry. In addition, SolarWorld is offering a product warranty, which has been extended to 10 years.*

*in accordance with the applicable SolarWorld Limited Warranty at purchase.
www.solarworld.com/warranty

MADE IN USA

UL 1703

ISO 9001
ISO 14001
Certified

SOLARWORLD

We turn sunlight into power.

solarworld.com

Sunmodule® Plus SW 275 mono

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

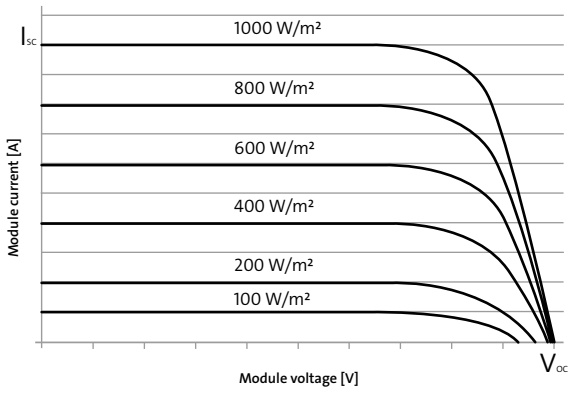
Maximum power	P_{max}	275 Wp
Open circuit voltage	V_{oc}	39.4 V
Maximum power point voltage	V_{mpp}	31.0 V
Short circuit current	I_{sc}	9.58 A
Maximum power point current	I_{mpp}	8.94 A

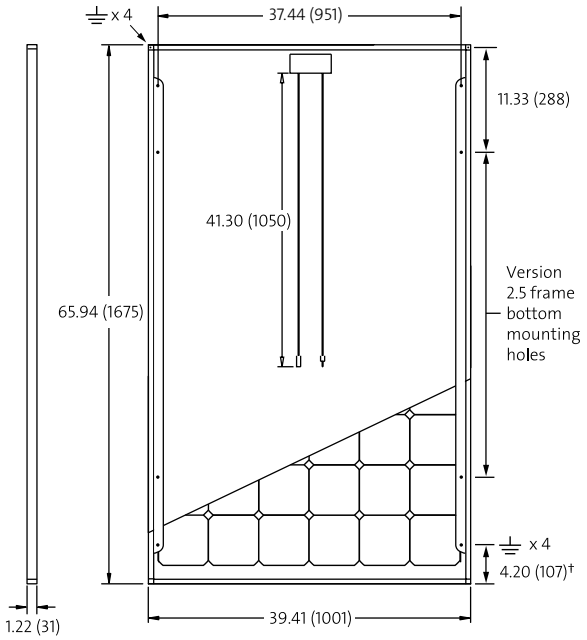
*STC: 1000 W/m², 25°C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled).

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.004 %/K
TC V_{oc}	-0.30 %/K
TC P_{mpp}	-0.45 %/K
Operating temperature	-40°C to 85°C





PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	205.0 Wp
Open circuit voltage	V_{oc}	36.1 V
Maximum power point voltage	V_{mpp}	28.4 V
Short circuit current	I_{sc}	7.75 A
Maximum power point current	I_{mpp}	7.22 A

Minor reduction in efficiency under partial load conditions at 25°C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	60
Cell type	Mono crystalline
Cell dimensions	6.14 in x 6.14 in (156 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	46.7 lbs (21.2 kg)

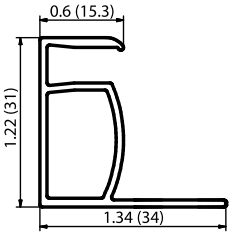
SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II		1000 V
Max. system voltage USA NEC		600 V
Maximum reverse current		16 A
Number of bypass diodes		3
UL Design Loads*	***Two rail system***	113 psf downward 64 psf upward
UL Design Loads*	***Three rail system***	170 psf downward 64 psf upward
IEC Design Loads*	***Two rail system***	113 psf downward 50 psf upward

* Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting[1]	-0 Wp / +5 Wp
J-Box	IP65
Connector	MC4
Module efficiency	16.40 %
Fire rating (UL 790)	Class C



VERSION 2.5 FRAME

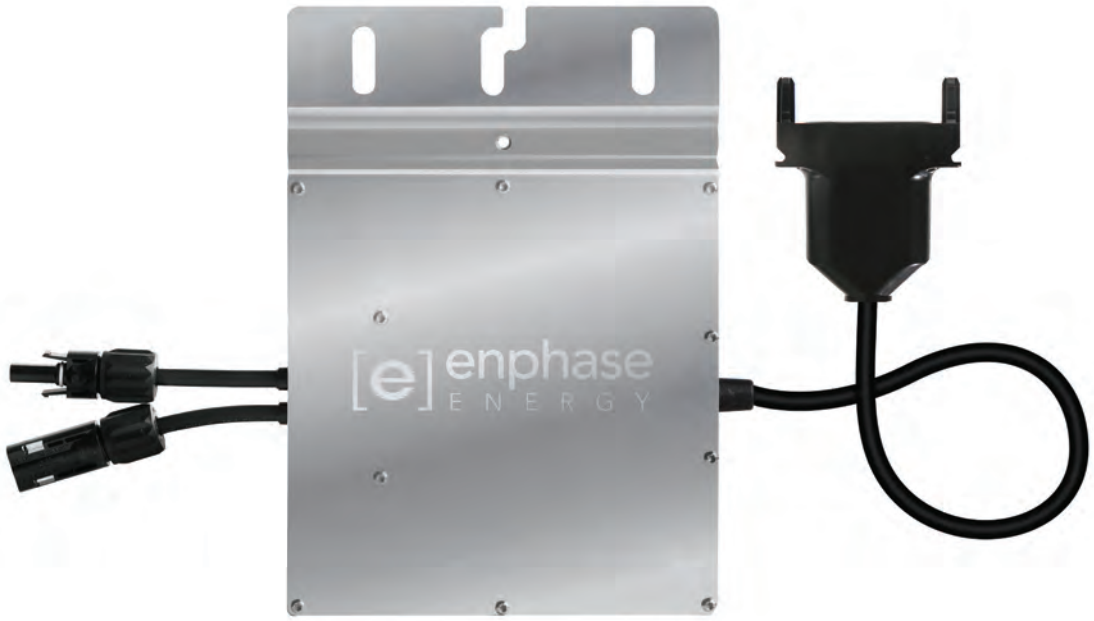
- Compatible with both "Top-Down" and "Bottom" mounting methods
- ⏚ Grounding Locations:
  - 4 corners of the frame
  - 4 locations along the length of the module in the extended flange†

NEW!

Independently created PAN files now available.
Ask your account manager for more information.

All units provided are imperial. SI units provided in parentheses.
SolarWorld AG reserves the right to make specification changes without notice.

Enphase® **M250**



The **Enphase® M250 Microinverter** delivers increased energy harvest and reduces design and installation complexity with its all-AC approach. With the M250, the DC circuit is isolated and insulated from ground, so **no Ground Electrode Conductor (GEC) is required for the microinverter.** This further simplifies installation, enhances safety, and saves on labor and materials costs.

The Enphase M250 integrates seamlessly with the Engage® Cable, the Envoy® Communications Gateway™, and Enlighten®, Enphase's monitoring and analysis software.

PRODUCTIVE

- Optimized for higher-power modules
- Maximizes energy production
- Minimizes impact of shading, dust, and debris

SIMPLE

- No GEC needed for microinverter
- No DC design or string calculation required
- Easy installation with Engage Cable

RELIABLE

- 4th-generation product
- More than 1 million hours of testing and 3 million units shipped
- Industry-leading warranty, up to 25 years

[e] enphase® ENERGY

C US

INPUT DATA (DC)	**M250-60-2LL-S22/S23/S24**	
Recommended input power (STC)	210 - 300 W	
Maximum input DC voltage	48 V	
Peak power tracking voltage	27 V - 39 V	
Operating range	16 V - 48 V	
Min/Max start voltage	22 V / 48 V	
Max DC short circuit current	15 A	
Max input current	9.8 A	
OUTPUT DATA (AC)	**@208 VAC**	**@240 VAC**
Peak output power	250 W	250 W
Rated (continuous) output power	240 W	240 W
Nominal output current	1.15 A (A rms at nominal duration)	1.0 A (A rms at nominal duration)
Nominal voltage/range	208 V / 183-229 V	240 V / 211-264 V
Nominal frequency/range	60.0 / 57-61 Hz	60.0 / 57-61 Hz
Extended frequency range*	57-62.5 Hz	57-62.5 Hz
Power factor	>0.95	>0.95
Maximum units per 20 A branch circuit	24 (three phase)	16 (single phase)
Maximum output fault current	850 mA rms for 6 cycles	850 mA rms for 6 cycles
EFFICIENCY		
CEC weighted efficiency, 240 VAC	96.5%	
CEC weighted efficiency, 208 VAC	96.0%	
Peak inverter efficiency	96.5%	
Static MPPT efficiency (weighted, reference EN50530)	99.4 %	
Night time power consumption	65 mW max	
MECHANICAL DATA		
Ambient temperature range	-40°C to +65°C	
Operating temperature range (internal)	-40°C to +85°C	
Dimensions (WxHxD)	171 mm x 173 mm x 30 mm (without mounting bracket)	
Weight	2.0 kg	
Cooling	Natural convection - No fans	
Enclosure environmental rating	Outdoor - NEMA 6	
FEATURES		
Compatibility	Compatible with 60-cell PV modules.	
Communication	Power line	
Integrated ground	The DC circuit meets the requirements for ungrounded PV arrays in NEC 690.35. Equipment ground is provided in the Engage Cable. No additional GEC or ground is required.	
Monitoring	Free lifetime monitoring via Enlighten software	
Compliance	UL1741/IEEE1547, FCC Part 15 Class B, CAN/CSA-C22.2 NO. 0-M91, 0.4-04, and 107.1-01	

* Frequency ranges can be extended beyond nominal if required by the utility

To learn more about Enphase Microinverter technology,
visit **enphase.com**

enphase® ENERGY

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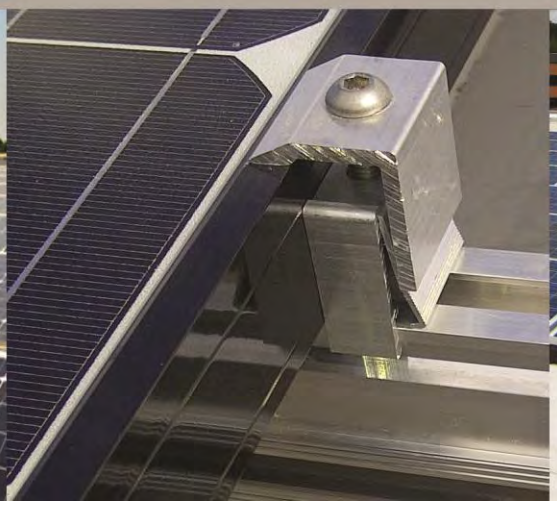
Renusol
Solar Mounting Systems

Product Catalog

Effective April 2013

Note: New items are highlighted in YELLOW



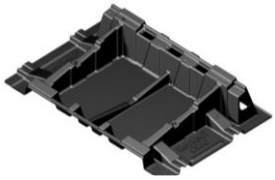
1292 Logan Circle
Atlanta, GA 30318
+1 877 847 8919

www.renusolamerica.com
info@renusolamerica.com

Renusol
Solar Mounting Systems

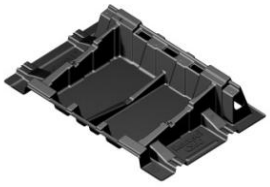
Renusol CS60

Ballasted Flat Roof System



10° Tilt System

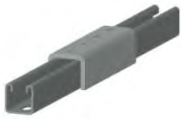
15° Tilt System

Picture	Part Number	Description	Quantity	Composed of
	**560089**	**Renusol CS60 10° Tilt**	**10-pack**	• 10 x Renusol CS60 10° HMWPE base and mounting hardware for 10° Renusol S60's
	560090	**Renusol CS60 10° Tilt**	**60-pack**	• 60 x Renusol CS60 10° HMWPE base and mounting hardware for 60 Renusol S60's
	460304	**Renusol CS60 10° Tilt- HL**	**40-pack***	• 40 x Renusol CS60 10° High Load HMWPE base and mounting hardware for 60 Renusol S60's
	*Min order qty: 480 pcs			
	560077	**Renusol CS60 15° Tilt**	**10-pack**	• 10 x Renusol CS60 15° HMWPE base and mounting hardware for 10 Renusol S60's
	560079	**Renusol CS60 15° Tilt**	**60-pack**	• 60 x Renusol CS60 15° HMWPE base and mounting hardware for 60 Renusol CS60's
	460222	**Renusol CS60 15° Tilt - HL**	**40-pack***	• 40 x Renusol CS60 15° High Load HMWPE base and mounting hardware for 40 Renusol CS60's
	*Min order qty: 480 pcs			
	500092	**Drill Jig**	**Each**	• 1 x adjustable drill jig for proper hole placement
	600036	**Accessory Hardware Kit (for micro inverter mounting, etc)**	**20-pack**	• 22 x ¼-20 clip nut • 22 x ¼-20 bolt 1.0" with self -locking patch • 22 x 1.25" OD x 0.281 ID x washer
	560094	**Anchor Bracket Kit**	**8-pack**	• 8 x anchor bracket assembly for roof anchoring **Flashing and roof screws are NOT included. These components need to be selected based on specific roof construction.**
	600403	**Assembly Tool Kit**	**Each**	• 1 x flexible drill shaft extension with right angled drive attachment

Questions, Call +1 877 847 8919 or email: info@renusolamerica.com

Renusol CS60 Additional Resources

Below is a list of possible tools/products that may assist your team in product installation. Renusol America does not guarantee or recommend any manufacturers' products. This list offers possible resources only. Each product use should be evaluated as the best tool for a particular project and installation team.

Picture	Item Suggestion	Part Number	Purpose	Online Information	Where To Find
	Solid Concrete Blocks suggested size: 4" x 8" x 16"	**Unknown**	**Product ballast if needed**	http://oldcastleproductguide.com/locations	**Distributors of Old Castle, etc.**
	Tyco Electronics Grounding Clip	**1954381-3**	**Module grounding**	http://www.te.com/catalog/products/en?q=1954381-3 **On other sites this item may be referenced as a Solklip. Please make sure to check the product number to verify correct part.**	**Distributors of Tyco Electronics**
	**Unistrut 12 gage 1 5/8 x 1 5/8 strut and U-shaped splice fitting. Use hot-dipped galvanized parts only.**	**Unistrut strut # P1000T-HG Unistrut Splice # P1377-HG**	**Connecting North/South if needed**	www.unistrut.us	**Distributors of Unistrut or competitors**
	EPDM Slip Sheet	**Variety of different manufacturers**	**Use if needed for roof surface**		**Distributors of commercial roofing. Also available through Allied Building Products.**

General information:

- All transactions according to 'Renusol America Inc. General Terms and Conditions of Sale'*
- All prices are in US$; customer discount to be deducted, including packaging, excluding VAT and freight charge.
- Payment terms are 'cash in advance', unless other terms have been agreed upon (after credit approval).
- Delivery Freight on Board (FOB) destination, Freight Prepaid and added to the invoice.
- We reserve the right to make changes in the form, technique, dimension, weight and material for the purpose of technical improvement.
- Errors and omissions excluded.
- With the present pricelist all previous pricelists have become invalid.

Renusol America Inc.
1292 Logan Circle NW
Atlanta, GA 30318

For further information: Info@renusolamerica.com
Toll-free: + 1 877 847 8919
Fax: +1 678 669 2743

Submit orders to: Order@renusolamerica.com

***Complete General Terms and Conditions of Sale and product warranties are listed in the following pages.**

General Terms & Conditions of Sale

1. General Provisions

1.1 All sales of the products and services of Renusol America Inc. ("Supplier") to buyers ("Customer"; Supplier and Customer are referred to individually as a "Party" or jointly as the "Parties") of Renusol America Inc. brand products are subject to these general terms and conditions of sale (this "Agreement").

1.2 No order will be accepted by Supplier until Customer has indicated in writing on a "Sales Order Confirmation" form, referred to below, that it has agreed to the terms of this Agreement.

2. Order Placement

2.1 A sales quotation given in response to any request is for the potential Customer's reference only and is not legally binding on either Party unless otherwise expressly stated therein.

2.2 All orders for the Renusol mounting systems and related accessories (the "Product") manufactured, assembled, or otherwise distributed by Supplier, must be received on a "Purchase Order" form selected by Customer or Supplier.

2.3 All orders must be submitted with a delivery date and ship-to address. If a delivery date is not listed on order, shipments will be held for up to 30 days only

3. Prices And Terms Of Payment

3.1 The price per Product (the "Purchase Price") shall be as set forth in a Sales Order Confirmation to be faxed or e-mailed to Customer for approval. Such Sales Order Confirmation will be prepared by Supplier after receipt from Customer of the Purchase Order confirming the quantity and delivery requirements of Customer. The Supplier's Sales Order Confirmation requires a signature from Customer in order for Supplier to proceed with the order.

3.2 Payments are due upon receipt, or **net 30 days** if customer has a credit agreement in place. Further discounts on Purchase price shall be applicable as special promotions, as announced on sales quotation form.

3.3 Upon completion of production of the Product prepared pursuant to the Sales Order Confirmation, Supplier will notify Customer by fax, e-mail, or phone that the order is ready for shipment upon receipt of the balance of the Purchase Price for the total order. Upon receipt of the payment for the entire amount of the Purchase Price, Supplier will promptly ship the Product to Customer in the manner specified in the Purchase Order and confirmed in the Sales Order Confirmation.

3.4 Unless specific arrangement is made for an extension of credit, payment is due prior to the time of delivery. Finance charges equal to the lesser of 1.5% per month (18% per annum) or the maximum rate permitted by applicable law may be assessed on payments received after delivery has been made from such delivery date to the date payment is received. If an extension of credit has been made, payment is due net the number of days set forth on the Sales Order Confirmation from the date delivery has been made (the "Payment Due Date"). An extension of credit shall be deemed to have been made whenever payment in full is not made prior to the time of delivery. Failure to make payments when due or remit finance charges when assessed may result in delayed or cancelled shipments. No unauthorized deductions from invoices are permitted.

3.5 Customer will also be required to pay all sales or use taxes unless satisfactory evidence of re-seller status or tax exempt form is provided to Supplier.

3.6 Supplier reserves the right to rescind and cancel the Sales Order Confirmation at any time if Customer breaches the payment terms referred to in this Section 3 of this Agreement.

3.7 The Purchase Price shall be paid in cash, either by wire transfer, check or other mutually agreed method. Additionally, to the extent lawful, and if approved by Supplier, all or any portion of the Purchase Price may be paid by an assignment by Customer to Supplier of rights to payment in respect of any incentive payments, rebates or similar payments available to Customer from third parties in connection with the installation of the Product (such payments and rebates are herein referred to as "Product Incentive Payments"). Customer shall be responsible for preparation and delivery of any documentation necessary to assign any Product Incentive Payments approved for payment by Supplier. Additionally, if any applicable third party fails to make any Product Incentive Payment at the time due (or expected to be due), Customer shall not be relieved from making such payment, and shall upon the request of Supplier promptly make such payment to Supplier.

4. Shipment Terms And Limitations

4.1 All risk of loss for damage to the Product ordered, in whole or in part, shall be borne entirely by Customer once the Product is delivered to a common carrier for delivery to Customer pursuant to the terms of the Sales Order Confirmation.

4.2 Any estimate by Supplier to Customer for the cost and time of delivery of the Product is only an estimate, and time of delivery shall be automatically extended by a reasonable period of time due to unforeseen causes beyond the responsibility of Supplier.

5. Miscellaneous Terms

5.1 The Sales Order Confirmation signed by both Parties may not be modified, amended or altered in any manner without the mutual written consent of both Parties.

5.2 This Agreement and any other documents referred to in this Agreement constitute the entire agreement between the Parties regarding the subject matter contained herein and shall supersede all previous oral or written agreement(s) between the Parties. **To the extent any other document, including a Purchase Order, is inconsistent with the terms of this Agreement, the terms of this Agreement shall prevail unless expressly acknowledged in the Sales Order Confirmation.**

6. Warranty And Limitation Of Liability

6.1 The warranty terms are set forth in the accompanying document titled "Renusol America, Inc., 10 Year Limited Product Warranty for Renusol VS" and/or "Renusol America, Inc., 25 Year Limited Warranty for Renusol CS60".

7. CHOICE OF LAW AND DISPUTE RESOLUTION

7.1 **Governing Law**. This Agreement and all documents executed and delivered in connection herewith shall be construed and enforced in accordance with the laws of the State of Georgia, except with respect to conflicts of laws principles.

7.2 Dispute Resolution.

7.2.1 **Arbitration**. Any disputes that cannot be resolved by the Parties themselves shall be resolved by binding arbitration in Atlanta, Georgia, conducted in accordance with the commercial arbitration rules of the American Arbitration Association. The arbitrator(s) in such arbitration shall be authorized and instructed to award to the prevailing Party, as part of its award, an amount equal to the prevailing Party's costs of arbitration, including, without limitation, reasonable attorneys' fees.

7.2.2 **Enforcement of Arbitral Award - Consent to Jurisdiction.** Each of the Parties hereby irrevocably consents and agrees that any legal action or proceedings brought to enforce any arbitral award granted pursuant to this Agreement may be brought in state and federal courts located in Atlanta, Georgia.

8. NOTICES

8.1 Any notice required by this Agreement or given in connection with it shall be in writing and shall be given to the appropriate Party by personal delivery or by certified mail, postage prepaid, or recognized overnight delivery services.

Renusol America, Inc. – 25 Year Limited Product Warranty for Renusol CS60

Renusol America, Inc. ("Seller") warrants to the original buyer ("Buyer") that this product(s) ("Product") shall be free from defects in material and workmanship. If the Product or any of its components is found defective during the Warranty Period, Seller will repair or replace, at Seller's sole discretion, the Product or component with the same or a similar model, which may be a reconditioned unit, without charge for parts or labor. This warranty ("Warranty") shall be in effect for a period of twenty-five (25) years from the earlier of: (i) the date that the initial installation of the Product is completed; or (ii) 30 days after the purchase of the Product by the Buyer (the "Warranty Period"). However, for specified components generally, or for a particular type of use of certain components, the term of the warranty may be shorter as expressly specified or provided for by Seller's individually-generated plans for the pertinent project. If a shorter warranty is specified as to any component, or if an exchange of a component is otherwise scheduled within a shorter period, the Warranty Period shall be restricted to such specified shorter period.

If you need service under this Warranty, you must, prior to the lapse of the Warranty Period, file a claim, together with proof of purchase and confirmation from you that you are the original purchaser of the Product, with Seller. This Warranty is conditioned upon your reasonably cooperating with Seller in the evaluation of your claim and the implementation of any remedy.

Seller's obligation to perform under this Warranty shall not apply if: (i) installation of the Product is not performed in accordance with Seller's written installation instructions and design specifications therein, as well as generally recognized standards and principles of building and constructions work; (ii) the Product has been modified, repaired, or reworked in a manner not previously authorized, in writing, by Seller; (iii) the Product has been utilized or handled in a manner that is inconsistent with any written instructions provided to the Buyer by the Seller; (iii) the Product is installed in an environment for which it was not designed or which contains corrosive atmospheric conditions (including without limitation, chemical fumes, salt water and wind-blown sand); or (iv) Buyer does not pay all invoices promptly as due in accordance with all purchase orders, invoices, or any other contract document related to the Product.

This Warranty shall not cover the following: (i) damage from any foreign residue deposited on the finish of the Product; (ii) damage to the Product that occurs during its shipment, storage, or installation; and (iii) damage that is covered or coverable by insurance against storm or similar natural events. Manufacturers of related items, such as PV modules and flashings, may provide written warranties of their own. Seller's limited Warranty covers only its Product, and not related items.

REPAIR OR REPLACEMENT OF ANY PRODUCT UNDER THIS WARRANTY SHALL COMPLETELY SATISFY AND DISCHARGE ALL OF SELLER'S LIABILITY WITH RESPECT TO THIS WARRANTY. SELLER SHALL NOT BE LIABLE FOR CONSEQUENTIAL, CONTINGENT OR INCIDENTAL DAMAGES ARISING OUT OF THE USE OF THE PRODUCT BY BUYER UNDER ANY CIRCUMSTANCES. SELLER MAKES NO WARRANTY THAT THE PRODUCT WILL BE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE, AND MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN.

This Warranty is expressly subject to Seller's General Terms and Conditions of Sale, which are incorporated herein by reference. This Warranty extends only to claims of the original Buyer, and third parties shall have no rights or benefits under this Warranty. This Warranty is non-assignable and non-transferable without the written consent of the Seller.

RSA 2/15/2012

Renusol America, Inc. – 10 Year Limited Product Warranty for Renusol VS

Renusol America, Inc. ("Seller") warrants to the original buyer ("Buyer") that this product(s) ("Product") shall be free from defects in material and workmanship. If the Product or any of its components is found defective during the Warranty Period, Seller will repair or replace, at Seller's sole discretion, the Product or component with the same or a similar model, which may be a reconditioned unit, without charge for parts or labor. This warranty ("Warranty") shall be in effect for a period of ten (10) years from the earlier of: (i) the date that the initial installation of the Product is completed; or (ii) 30 days after the purchase of the Product by the Buyer (the "Warranty Period"). However, for specified components generally, or for a particular type of use of certain components, the term of the warranty may be shorter as expressly specified or provided for by Seller's individually-generated plans for the pertinent project. If a shorter warranty is specified as to any component, or if an exchange of a component is otherwise scheduled within a shorter period, the Warranty Period shall be restricted to such specified shorter period.

If you need service under this Warranty, you must, prior to the lapse of the Warranty Period, file a claim, together with proof of purchase and confirmation from you that you are the original purchaser of the Product, with Seller. This Warranty is conditioned upon your reasonably cooperating with Seller in the evaluation of your claim and the implementation of any remedy.

Seller's obligation to perform under this Warranty shall not apply if: (i) installation of the Product is not performed in accordance with Seller's written installation instructions and design specifications therein, as well as generally recognized standards and principles of building and constructions work; (ii) the Product has been modified, repaired, or reworked in a manner not previously authorized, in writing, by Seller; (iii) the Product has been utilized or handled in a manner that is inconsistent with any written instructions provided to the Buyer by the Seller; (iii) the Product is installed in an environment for which it was not designed or which contains corrosive atmospheric conditions (including without limitation, chemical fumes, salt water and wind-blown sand); or (iv) Buyer does not pay all invoices promptly as due in accordance with all purchase orders, invoices, or any other contract document related to the Product.

This Warranty shall not cover the following: (i) damage from any foreign residue deposited on the finish of the Product; (ii) damage to the Product that occurs during its shipment, storage, or installation; and (iii) damage that is covered or coverable by insurance against storm or similar natural events. Manufacturers of related items, such as PV modules and flashings, may provide written warranties of their own. Seller's limited Warranty covers only its Product, and not related items.

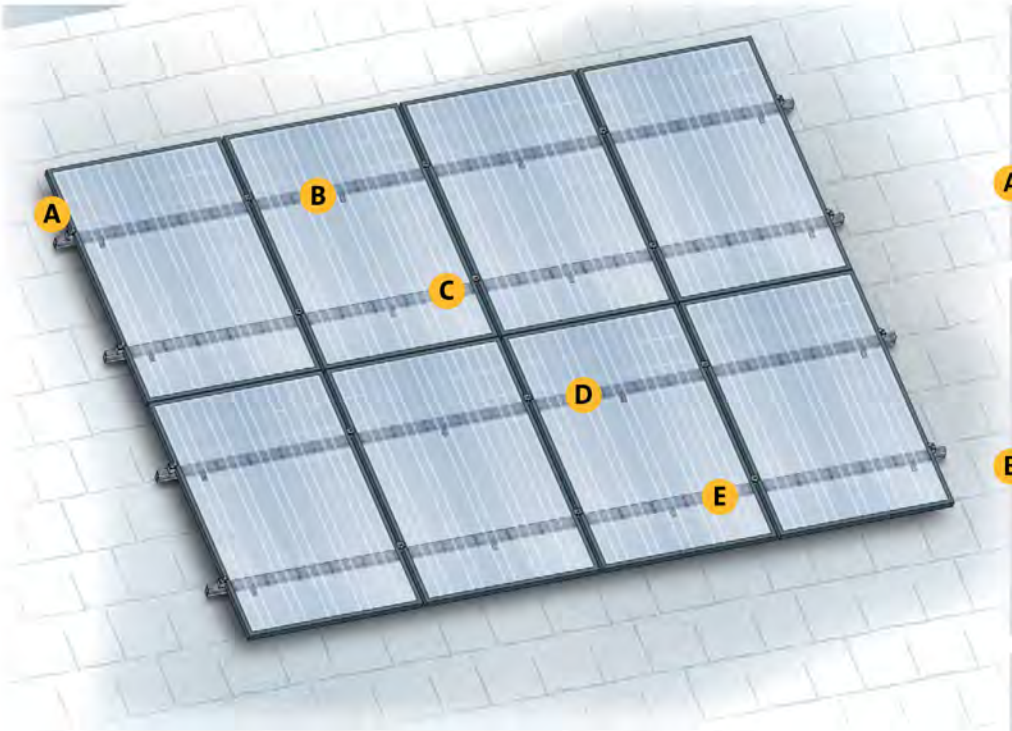
REPAIR OR REPLACEMENT OF ANY PRODUCT UNDER THIS WARRANTY SHALL COMPLETELY SATISFY AND DISCHARGE ALL OF SELLER'S LIABILITY WITH RESPECT TO THIS WARRANTY. SELLER SHALL NOT BE LIABLE FOR CONSEQUENTIAL, CONTINGENT OR INCIDENTAL DAMAGES ARISING OUT OF THE USE OF THE PRODUCT BY BUYER UNDER ANY CIRCUMSTANCES. SELLER MAKES NO WARRANTY THAT THE PRODUCT WILL BE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE, AND MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN.

This Warranty is expressly subject to Seller's General Terms and Conditions of Sale, which are incorporated herein by reference. This Warranty extends only to claims of the original Buyer, and third parties shall have no rights or benefits under this Warranty. This Warranty is non-assignable and non-transferable without the written consent of the Seller.

RSA 2/15/2012

Renusol VS

Solar PV Mounting System For Pitched Roof Applications



The Renusol VS system provides a simple, fast and cost effective mounting solution for PV modules on pitched roofs.

- Just one end clamp and one mid clamp part number simplifies inventory and project planning.
- Pre-assembled clamps, fastener-free splice connectors, and slide-free L-feet minimize installation time.
- Anti-slip hardware and bolt alignment indicators ensure installation confidence.
- Stainless steel hardware and 6000 series aluminum rails provide strength and long product life.
- High strength-to-weight ratio rail design keeps cost low while allowing long spans.
- WEEB-CCR offers continuous grounding of panels to rails.

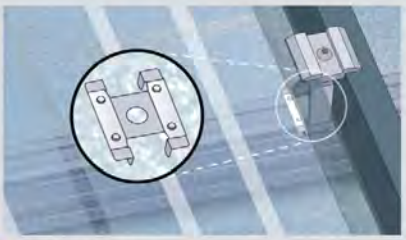
About Renusol

Renusol America is a leading innovator in flat-roof and pitch-roofed mounting systems for Solar PV modules in the US solar industry. Renusol America provides sales, service, and customer support from its headquarters in Atlanta, Georgia and through a network of authorized distributor partners across the country. The company is part of the Centrosolar Group, a publicly traded company on the German stock exchange, and is a wholly owned subsidiary of Renusol GmbH, a market leader in Europe with close to 1GW of solar power mounted on Renusol systems.

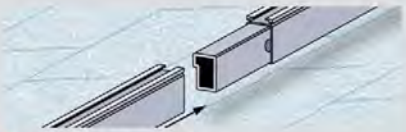
FEATURES

A End Clamp
- Clamp range from 30 to 50mm
- Fits 97% of all modules

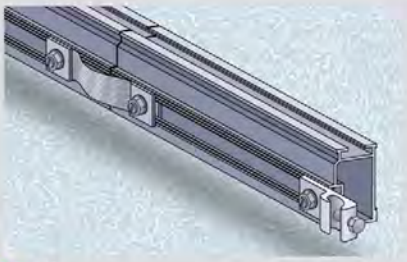
B L-Foot
- Insert anywhere without sliding
- Offset T-bolt slot for easier mounting or fastening
- Bolt alignment indicator ensures proper alignment



C Mid Clamp
- Clamp range: 30 to 50mm
- Fits 97% of all modules
- WEEB-CCR provides continuous grounding of panels to rails



D Splice Connector
- Presets rail gaps for thermal expansion
- No fastening equals quick installation



E Rail
- Continuous spans up to 12 feet
- Rail approved for side mounting of WEEBs

Renusol Solar Mounting Systems

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Installation Manual

Enphase Engage Cable and Accessories

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Other Information

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Table of Contents

Important Safety Information 5
Read this First 5
Safety Instructions 5
For Your Safety 5
Electrical Installation 5
The Enphase Engage Cable and Accessories 7
Compatibility 7
Parts and Tools Required 7
Lightning Surge Protection 7
Selecting Cable Type 8
Connector Spacing Options 8
Voltage Types and Conductor Count 9
Racking Compatibility 9
Cabling Length Options 9
Planning for Cable Lengths and Type 10
Enphase Engage Cable and Accessories Installation 11
Installation Procedure 12
Step 1 – Measure AC at Service Entrance Conductors 12
Step 2 – Install the AC Branch Circuit Junction Box 13
Step 3 – Position the Enphase Engage Cable 14
Step 4 – Attach the Microinverters to the Racking 14
Step 5 – Dress the Engage Cable 15
Step 6 – Terminate the Unused End of the Engage Cable 17
Attaching the Terminator 17
Replacing or Removing the Terminator 19
Step 7 – Connect the Engage Cable to Junction Box(es) 19
Step 8 – Verification and Commissioning 21
Disconnecting a Microinverter from the Engage Cable 22
Technical Data 23
Appendix – Sample Wiring Diagrams 25
Sample Wiring Diagram – 240 Vac 25
Sample Wiring Diagram – 208 Vac 26

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Important Safety Information

Read this First

To reduce the risk of electrical shock, and to ensure the safe installation and operation of the Enphase System, the following safety indications appear throughout this document.

⚠ DANGER	Indicates a hazardous situation, which if not avoided, **will** result in death or serious injury.
⚠ WARNING	Indicates a hazardous situation, which if not avoided, **could** result in death or serious injury.
⚠ CAUTION	Indicates a hazardous situation which, if not avoided, **could** result in minor or moderate injury.
NOTICE	Follow instructions closely to avoid damage or malfunction to the device and/or damage to surrounding property.

Safety Instructions

For Your Safety

⚠ DANGER	**Risk of Electrical Shock**. Do NOT connect or disconnect the photovoltaic module from the Enphase Microinverter without first removing AC power from the photovoltaic system.

Electrical Installation

⚠ WARNING	Be aware that only trained solar professionals should install and/or replace the Enphase Cabling System or connect the Enphase Microinverter to the electrical utility grid.
⚠ WARNING	Perform all electrical installations in accordance with all local electrical codes and the National Electrical Code (NEC), ANSI/NFPA 70.
⚠ WARNING	The AC connectors on the cabling are rated as a disconnect only when used with an Enphase Microinverter.
⚠ WARNING	Connect the Enphase Microinverter to the electrical utility grid only after receiving prior approval from the utility company and any applicable AHJ (authority having jurisdiction).
NOTICE	Before installing the cabling, read all instructions and cautionary markings in the user manual, on the Enphase equipment, and on the all other photovoltaic equipment.

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The Enphase Engage Cable and Accessories

The Engage Cable is a continuous length of 2.5 mm2 (12 AWG), outdoor rated cable with integrated connectors for microinverters. These connectors are preinstalled along the Engage Cable at intervals to accommodate PV module widths. The microinverters plug directly into the cable connectors.

Compatibility

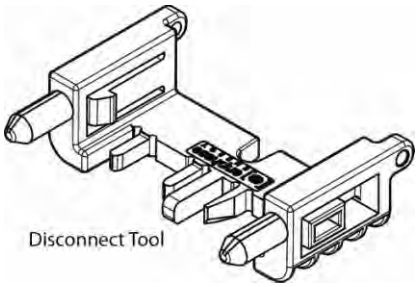
The cabling is compatible with a variety of PV racking systems. For a list of approved PV racking systems, refer to the PV Racking Compatibility document on the Enphase website (http://www.enphase.com/support/downloads).

Parts and Tools Required

In addition to the Enphase microinverters, PV modules, PV racking, and associated hardware, you will need the following items.

Enphase equipment:

- Enphase Engage Cable. See Selecting Cable Type on page 8 for options.
- Watertight sealing caps, as needed (for any unused drops on the cable)
- Terminators, as needed (for AC branch circuit cable ends)
- Cable clips
- Enphase disconnect tool (number 2 Phillips screwdriver can be substituted)



Other items:

- Outdoor-rated, weather-proof AC junction box(es)
- Grounding conductor
- Torque wrench, sockets, wrenches for mounting hardware
- Adjustable wrench or open ended wrench (for terminators)

Lightning Surge Protection

Lightning protection and resulting voltage surge are protected in accordance with EN 62305-1. It is assumed that the PV modules are installed in accordance with related standards and that the microinverter is a part of a broader lightning mitigation system in accordance with EN 62305-1, -3.

In some areas, the statistical frequency of lightning strikes near a PV installation is high enough that lightning protection must be installed as part of an Enphase system. In some areas, a surge protection device might be mandatory following a risk analysis, according NFC 15-100 (art. 443) & NFC 15-443L.

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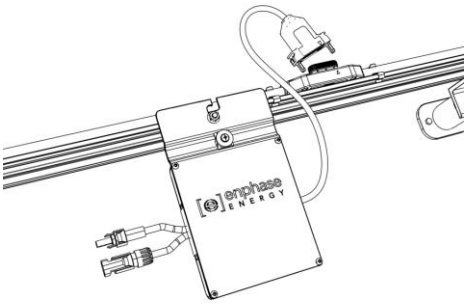
Selecting Cable Type

Enphase Engage Cable is available in two different voltage types and two connector spacing options. Depending upon installer needs, the cable is also available in different lengths.

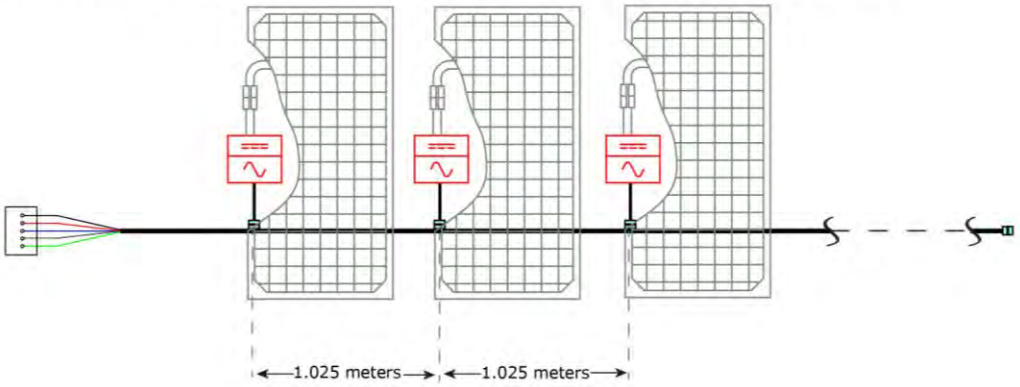
The cable is installed by simply rolling out the desired length of cable and cutting it to size. One end is wired directly into the junction box at the head of the branch circuit, eliminating the need for a separate AC interconnect cable. The other end is sealed from the environment using an Enphase Branch Terminator. The microinverter AC cable connectors are then plugged into the regularly-spaced connectors as shown.



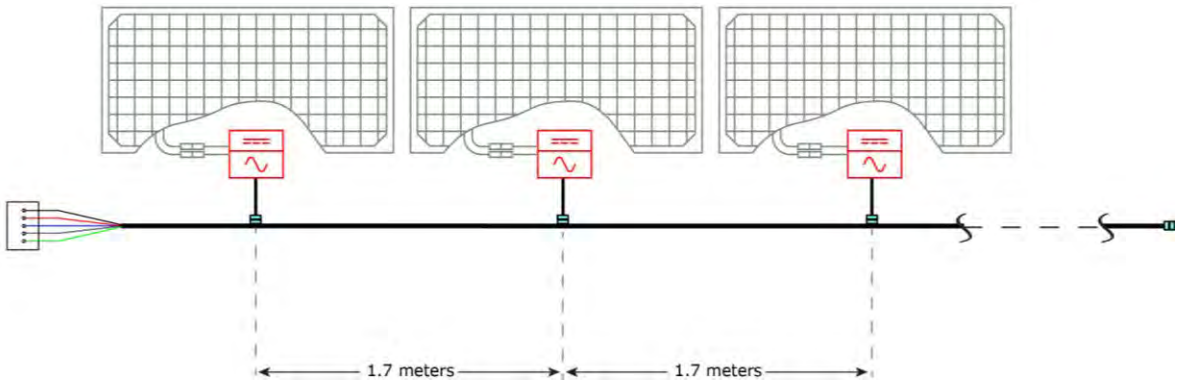
Connector Spacing Options

The gap between connectors on the cable can be either 1.025 meters (40″) or 1.7 meters (67″). The 1.025 meter spacing is best suited for connecting PV modules installed in portrait orientation, while the 1.7 meter gap is best suited to PV modules installed in landscape orientation.

Cabling with connectors spaced at 1.025 meter (40″) for PV modules in portrait orientation



Cabling with connectors spaced at 1.7 meters (67″) for PV modules in landscape orientation



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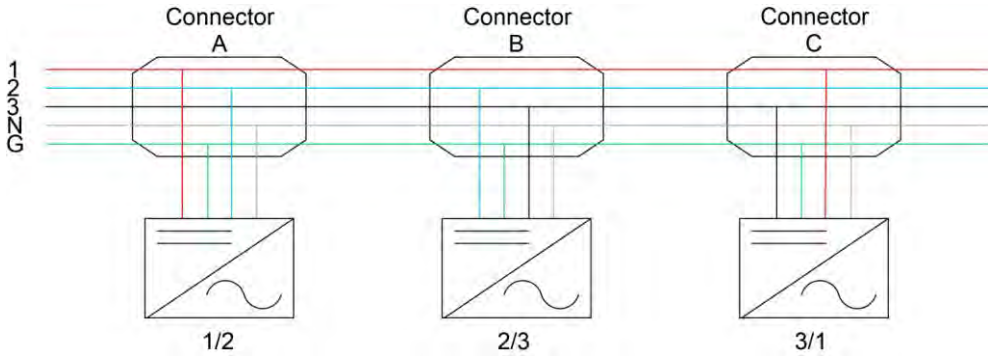
Voltage Types and Conductor Count

The voltage types are either 240VAC split phase or 208VAC three phase. **All cable connectors bear labels indicating their cable voltage designation.** Typically used for residential applications, 240VAC includes four conductors. This cabling should also be used for split phase 208VAC applications. Three-phase 208VAC cabling includes five conductors, and is used for most commercial installations. Because Enphase microinverters output onto two phases, three phase cabling balances the phases by rotating conductor use from one microinverter to the next as shown in the following diagram. In the diagram, the three phases are labeled 1, 2, and 3.



Racking Compatibility

Engage Cabling is compatible with a variety of racking systems. For a list of approved PV module racking types, refer to the Racking Compatibility document at (http://www.enphase.com/support/downloads).

Cabling Length Options

Engage Cabling is available in shorter lengths with 30-40 connectors, depending upon voltage type. Longer lengths can be ordered and cut to suit per order. Ordering options include:

Model Number	Voltage type/ conductor #	Connector count	Connector spacing	PV module orientation	Approx. weight
ET10-240-40	240VAC, 4 conductor	40	1.025 m (40″)	Portrait	18.1 kg (40 lbs)
ET17-240-40	240VAC, 4 conductor	40	1.7 m (67″)	Landscape	20.4 kg (45 lbs)
ET10-208-30	208VAC, 5 conductor	30	1.025 m (40″)	Portrait	13.6 kg (30 lbs)
ET17-208-30	208VAC, 5 conductor	30	1.7 m (67″)	Landscape	15.9 kg (35 lbs)
ET10-240-BULK	240VAC, 4 conductor	240	1.025 m (40″)	Portrait	over 90 kg (200 lbs)
ET17-240-BULK	240VAC, 4 conductor	240	1.7 m (67″)	Landscape	over 90 kg (200 lbs)
ET10-208-BULK	208VAC, 5 conductor	240	1.025 m (40″)	Portrait	over 90 kg (200 lbs)
ET17-208-BULK	208VAC, 5 conductor	240	1.7 m (67″)	Landscape	over 90 kg (200 lbs)

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Planning for Cable Lengths and Type

The Cabling System is flexible enough to adapt to almost any solar design. To determine the length and cable type that you need, take into account the following considerations:

- **The number of Enphase Microinverters to be installed on the AC branch circuit**. Be certain to allocate the correct number of connectors, including extra connectors for gaps and turns.
- **Additional length required to reach from the AC branch circuit junction box to the first microinverter**. If greater than half a connector interval is needed, it may be necessary to allow for one (or more) unused connectors in order to span this distance. Unused connectors must be covered with Enphase watertight sealing caps.
- **Additional length required to reach from one row of PV modules to the next.** If the PV modules are laid out in multiple rows, the distance from one row to the next often requires additional cabling length.
- **Bend radius**. When planning cabling turns or loops, you must account for a minimum bend radius of 6.7 cm (2.625″).
- **Multiple sub-arrays**. Often, the AC branch circuit may be composed of several smaller sub-arrays across more than one roof plane. In this case, the cable is cut to service each smaller array, and the sub-arrays are connected together using appropriately rated lengths of conduit. The transition from cable to conduit is accomplished using an outdoor rated AC junction box, as required by the NEC and local code. Unused connectors must be covered with Enphase watertight sealing caps.
- **Mixture of PV modules in both portrait and landscape orientation**. When PV modules are installed in mixed orientation (both portrait and landscape orientation), there are three choices for cabling:

    1. Cabling with 1.025 meter spacing between connectors results in cleanest install for the PV modules in portrait orientation. For PV modules placed in landscape orientation, plan for an unused connector between each PV module to accommodate the required additional distance. Unused connectors must be covered with Enphase watertight sealing caps.
    2. Cabling with 1.7 meter spacing between connectors results in cleanest install for PV modules in landscape orientation, but requires that any additional cable length between PV modules in portrait orientation be coiled and dressed so that cabling does not contact the roof. Again, unused connectors must be covered with Enphase watertight sealing caps.
    3. Another solution when PV modules are installed in mixed orientation is to transition between 1.025 and 1.7 meter spacing cable options using an outdoor rated junction box. This junction box can be installed to the PV racking.

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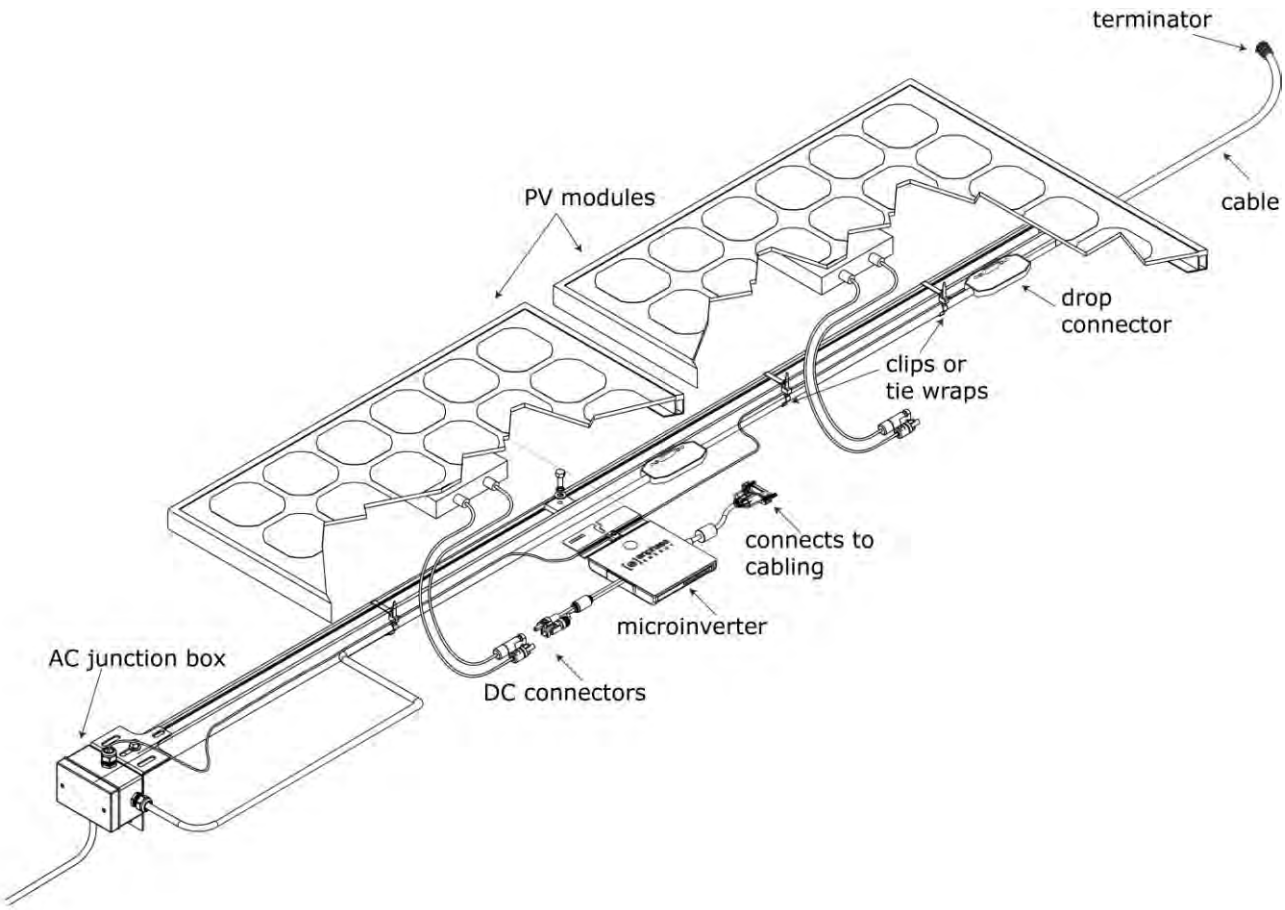
Enphase Engage Cable and Accessories Installation

Follow the instructions in this section to install the Engage Cable.

For information on microinverter installation, refer to the *M215 Installation and Operation Manual* at http://www.enphase.com/support/downloads.



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Installation Procedure

Installing the Engage Cable and Accessories involves several key steps:

1. Measure AC at Service Entrance Conductors
2. Install the AC Branch Circuit Junction Box
3. Position the Engage Cable
4. Attach the Microinverters to the Racking
5. Dress the Engage Cable
6. Terminate the Unused End of the Engage Cable
7. Connect the Engage Cable to Junction Box(es)
8. Verification and Commissioning

⚠ DANGER **Risk of Electrical Shock.** Due to presence of exposed conductors, DO NOT connect the Enphase Microinverters to the utility grid or energize the AC circuit(s) until you have completed all of the installation procedures as described in the following sections.

Step 1 – Measure AC at Service Entrance Conductors

Measure AC line voltage at the service entrance conductors. Acceptable ranges are shown in the following table.

240 Volt AC Split Phase		208 Volt AC 3 Phase	
L1 to L2	211 to 264 Vac	L1 to L2 to L3	183 to 229 Vac
L1, L2 to neutral	106 to 132 Vac	L1, L2, L3 to neutral	106 to 132 Vac

NOTICE Be sure the Engage Cable you are using matches the service at the site. Use 208Vac cabling at sites with three-phase 208Vac service, or use 240Vac cabling at sites with 240Vac service. Check the labeling on the cable drop connectors to verify the cable type.

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Step 2 – Install the AC Branch Circuit Junction Box

DANGER **Risk of Electrical Shock**. Be aware that installation of this equipment includes risk of electric shock. Do not install the junction box without first removing AC power from the Enphase System.

NOTICE Use electrical system components approved for wet locations only.

NOTICE When stripping off the cable sheath, make sure that the conductors are not damaged.

NOTICE Do not weigh down the cabling system.

NOTICE Loose cables might become a tripping hazard. Attach the power cables correctly.

NOTICE Do NOT exceed the maximum number of microinverters in an AC branch circuit as listed on page 7 of this manual, and protect each microinverter AC branch circuit with a 20 A maximum breaker.

a. Size the AC wire gauge to account for voltage drop. Select the correct wire size based on the distance from the beginning of the microinverter branch circuit to the breaker in the load center.

All components of system wiring must be considered, including internal voltage drop within the length of Engage Cable. Typically, three wire sections and several wire terminations must be quantified. There is also some resistance associated with each OCPD (OverCurrent Protective Device), typically a circuit breaker. As all of these resistances are in series, they add together. Since the same current is flowing through each resistance, the total voltage drop is total current times the total resistance. For a split-phase system, the total resistance is equal to two times the one-way resistance. For a three-phase system, each of the three line currents and resistances must be calculated.

NOTICE NEC guidelines for voltage drop on feeder and branch circuit conductors will not be sufficient for microinverter branch circuits that contain the maximum allowable microinverters. This is due to high inherent voltage rise on the branch circuit.

For more information, refer to the *Voltage Drop Calculations* Application Note at http://www.enphase.com/support/downloads.

b. Install an outdoor rated, weather-proof junction box at a suitable location on the PV racking system (typically at the end of a row of modules).

c. Provide an AC connection from the junction box back to the utility interconnection, using equipment and practice as required by the NEC and local jurisdictions.

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Step 3 – Position the Enphase Engage Cable

NOTICE

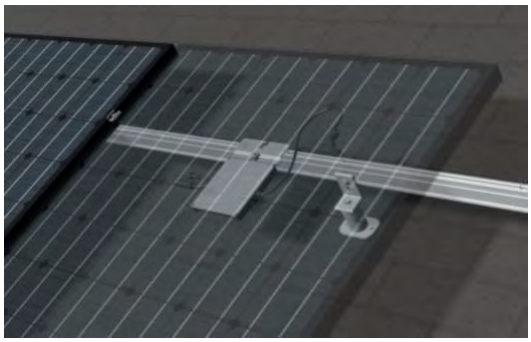
Many modules have a central stiffening brace. In these cases, do **not** position the connector and microinverter at the exact center of the PV module, but position the cable so that connectors do not conflict with the braces.

a. Lay the cabling along the route it will travel, positioning the connectors so that they align with the PV modules.

b. Module widths vary by manufacturer. On the Engage Cable, connectors are spaced at intervals to allow for the widest PV modules compatible with Enphase Microinverters. If narrower modules are used, it may be necessary to account for excess cable by adding a loop of cable at suitable intervals.

Step 4 – Attach the Microinverters to the Racking

a. **Mount the microinverters according to the microinverter manual.** Ensure both that the microinverter does not interfere with the PV module frames or stiffening brace, and that the drop cable from the microinverter can easily reach the connector on the cable.



b. Ground the microinverters using either a continuous, unbroken grounding conductor or approved grounding washers. Follow the methods described in the *M215 Installation and Operation Manual* at http://www.enphase.com/support/downloads.

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Step 5 – Dress the Engage Cable

NOTICE **Adhere to the following requirements:**

- Do not expose the connection to directed, pressurized liquid (water jets, etc.).
- Do not expose the connection to continuous immersion.
- Do not expose the AC connector to continuous tension (e.g., tension due to pulling or bending the cable near the connection)
- Use only the connectors and cables provided.
- Do not allow contamination or debris in the connectors.
- Use the cable and connectors only when all parts are present and intact.
- Fit the connection using only the prescribed tools.
- There are two release holes in the cable connector. These holes are used to disconnect the connector. **Keep these release holes clear and accessible.**

a. Attach the Engage Cable to the rack using the included clips, or you may use tie wraps. The cable clips are designed so that the drop cable from the microinverter can also be dressed into the clip underneath the cable.

b. Dress any excess cabling in loops so that cabling does not contact the roof.

⚠WARNING **Tripping Hazard**. Do **not** leave the cabling to rest on the roof. Loose cables might become a tripping hazard. Attach the power cables correctly.

c. Place tie wraps or clips on either side of the drop connector. Use one or two additional clips, tie wraps, or other support scheme to secure the cable between connectors.

d. Remove the temporary shipping cap from the Engage Cable.

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Step 5 – Dress the Engage Cable (continued)

e. Connect the microinverter and listen for two clicks as the two prongs engage. Ensure that **both** latching mechanisms have engaged.

NOTICE

The connector has not been designed for repeated linking and unlinking.

f. Repeat steps **a** through **e** for all microinverters in the branch.

g. Cover any unused connector with a watertight sealing cap. Listen for two clicks as the connectors engage. Ensure that **both** latching mechanisms have engaged.

NOTICE

Make sure watertight sealing caps are installed on **all** unused AC connectors. Unused AC connectors are live when the system is energized by the utility.

NOTICE

Do not use the shipping cap to cover unused connectors. The shipping cap does not provide an adequate environmental seal. Enphase watertight sealing caps (included in the Installation Kit) are required for protection against moisture ingress.

NOTICE

Enphase watertight sealing caps are IP67 rated. Within the term "IP67", "IP" indicates an Ingress Protection (IP) rating against dust and liquids. This specific rating of IP67 indicates that this connector protects against all dust particles and immersion in liquid.

NOTICE

If you need to remove a watertight sealing cap, you must use the Enphase disconnect tool or a #2 Phillips screwdriver.

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Step 6 – Terminate the Unused End of the Engage Cable

Attaching the Terminator

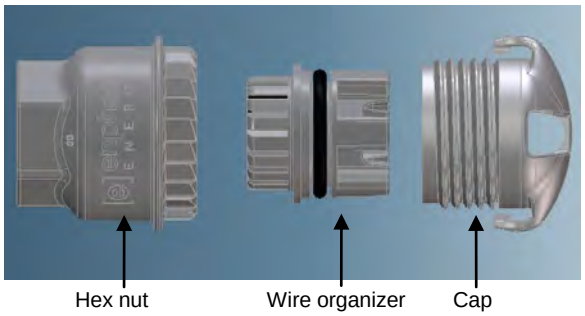
NOTICE The terminator is intended for one-time use only. If you open the terminator following installation, the latching mechanism is destroyed and the terminator cap cannot be used again. If the latching mechanism is defective, the terminator must not be used. The latching mechanism must not be circumvented or manipulated.

NOTICE **Adhere to the following requirements:**

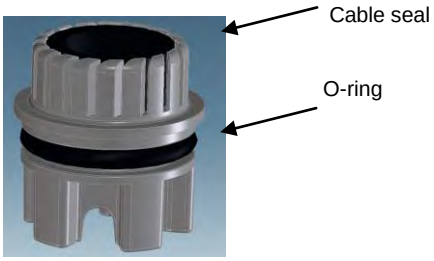
- Use of the terminator assembly is the only method allowed to seal the conductor end of the trunk.
- Do not expose the terminator cap to directed, pressurized liquid (water jets, etc.).
- Do not expose the terminator cap to continuous immersion.
- Do not expose the terminator cap to continuous tension (e.g., tension due to pulling or bending the cable near the terminator cap)
- Do not install or use in potentially explosive environments.
- Do not allow the terminator to come into contact with open flame.
- Use the terminator cap assembly only when all parts are present and intact.
- Fit the terminator cap using only the prescribed tools.

To attach the terminator:

a. Check the terminator cap assembly for completeness. It is made up of the individual parts shown.



b. To guarantee the safety of the wire organizer and to ensure that it remains sealed, please make sure that all parts are present and that all seals are seated correctly in the wire organizer.



The wire organizer must be complete, as shown.

DANGER **Risk of Electrical Shock.** The terminator cap must not be installed while power is connected.

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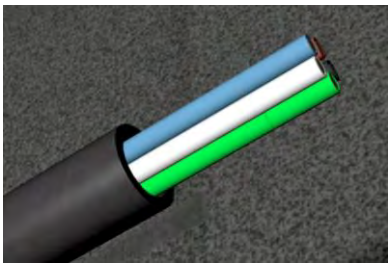
c. Strip at least 60 mm (2.5 inches) of the shielding from the conductors.

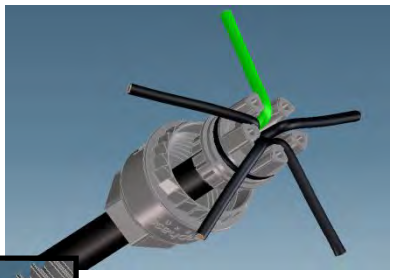


NOTICE If the exposed wires are damaged, system function can no longer be guaranteed.

d. Slide the hex nut onto the cable.

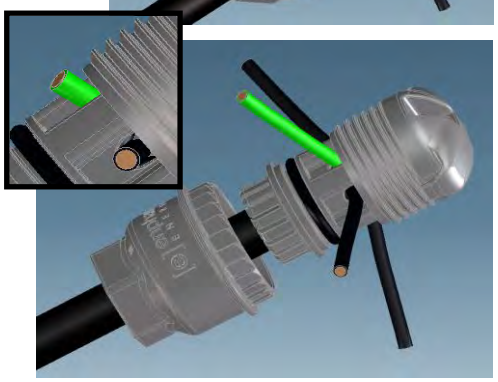
e. Insert the cable all the way into the wire organizer (up to the stop).

f. Bend the individual wires into the slots (spaces) on the wire organizer.



g. Using a diagonal cutter, trim wires to the correct length so that they fit cleanly into the slots (spaces) in the wire organizer.

h. Press the cap onto the wire organizer, bending the wires into the slots of the wire organizer.



If the wires resist being pressed into the cap, you may need to trim the wires a little further using a diagonal cutter.

i. Screw the hex nut onto the cap.

NOTICE Never unscrew the hex nut as this can twist and damage the cable.

j. Insert a #2 Philips screwdriver into the slot on the cap to hold it in place. (Alternatively you can hold the cap firmly in place using the Enphase hand tool).

k. Use a 24mm (7/8 inch) wrench and tighten the nut until the latching mechanism has been screwed all the way to the base.

l. Use a tie wrap or cable clip to attach the cable to the racking, so that the cable and terminator do not touch the roof.

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Replacing or Removing the Terminator

If the terminator must be replaced or removed, observe the following.

DANGER **Risk of Electrical Shock.** Never open, remove or replace the terminator while it is connected to the power supply.

NOTICE Damage to the latching mechanism **cannot** be seen with the naked eye. Label the opened terminator and dispose of it immediately to ensure that it cannot be reused accidentally.

NOTICE The terminator is intended for **one-time use only**. If you open the terminator again following the installation, this will destroy the latching mechanism, meaning that the unit then **cannot** be used again.

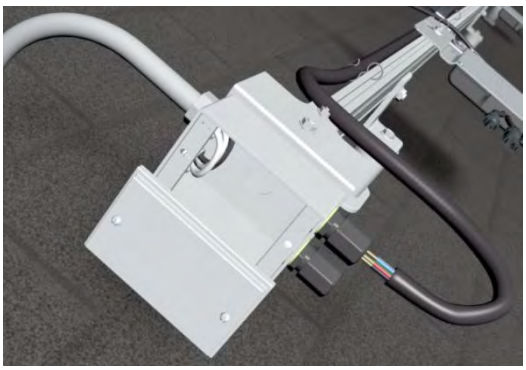
a. Remove the terminator by cutting it off using a diagonal cutter set flush against the end of the cable.

b. Replace the terminator as described in the previous steps, beginning on page 17.

Step 7 – Connect the Engage Cable to Junction Box(es)

NOTICE Perform the following steps in accordance with NEC regulations.

a. Connect Engage Cable into the AC branch circuit junction box using an appropriate gland or strain relief fitting. The cable requires a strain relief connector with an opening of 1.3 cm (0.5 inches) in diameter.



b. Connect the Engage Cable into additional junction boxes as needed to transition to conduit between smaller sub-arrays. Remember to adhere to branch limits for the microinverters being used.

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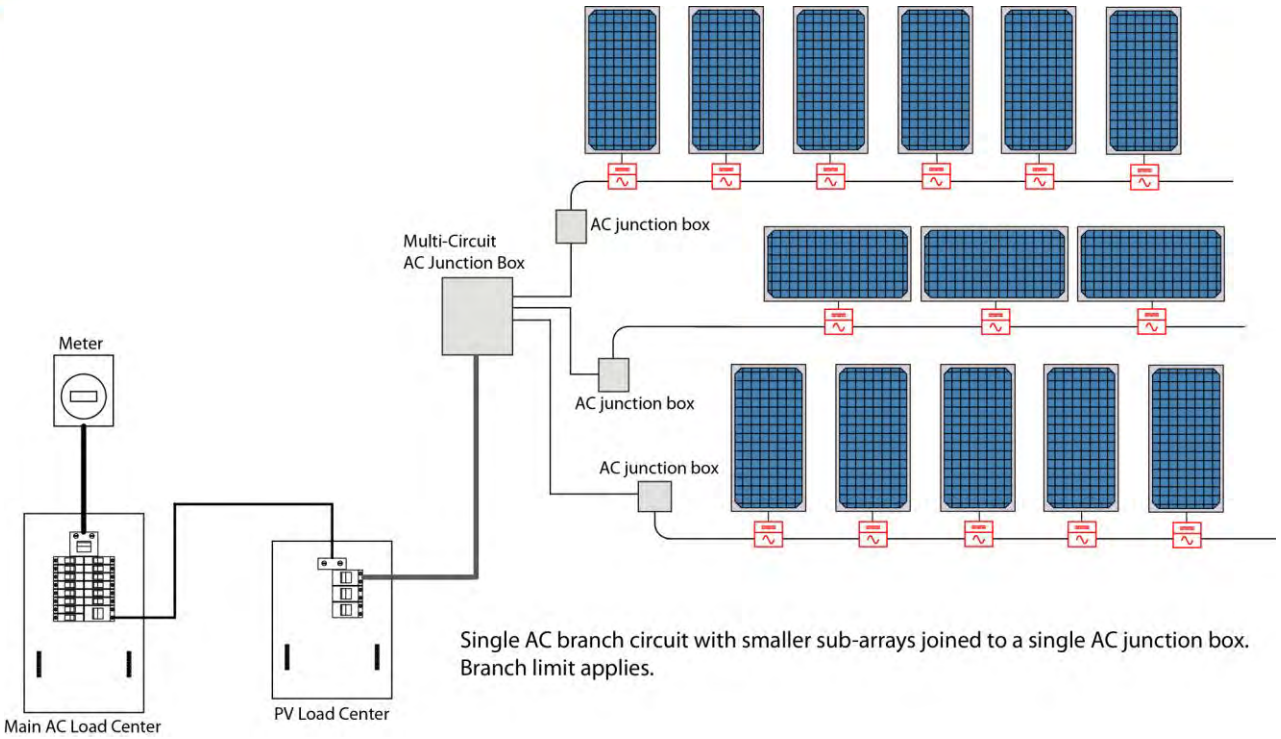

Single AC branch circuit with smaller sub-arrays joined to a single AC junction box. Branch limit applies.

Refer to the wiring diagrams located in the Appendix of this manual for more information.

NOTICE The Engage Cable uses a different wiring scheme than used with other Enphase Microinverters. Be aware of the difference in wire color code.

The 12 AWG conductors are identified as follows: L1 is sheathed in Black, L2 is sheathed in red, L3 is sheathed in blue (208 Vac only), Neutral is sheathed in white, and Ground is sheathed in green. The grounding wire is used to ground the microinverters. A WEEB or continuous ground is required in addition to this green grounding wire.

Balanced 208 VAC is accomplished by alternating phases between microinverters.

240 Volt AC Split Phase Wiring	208 Volt AC Three-Phase Wiring
Black – L1 Red – L2 White – Neutral Green - Ground	Black – L1 Red – L2 Blue – L3 White – Neutral Green - Ground

The green wire acts as equipment ground. A continuous GEC for system ground is also required as described in the next step.

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Step 8 – Verification and Commissioning

NOTICE **Prior to final connection to the utility grid, ensure that all AC and DC wiring is correct.**

a. Ensure that none of the AC and DC wires are pinched or damaged.

b. Ensure that all junction boxes are properly closed.

c. Ensure that all unused connectors are capped.

d. Ensure that all connectors are properly seated.

e. Install the microinverters and commission the system as instructed by the Enphase Microinverter installation and operation manual.

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Disconnecting a Microinverter from the Engage Cable

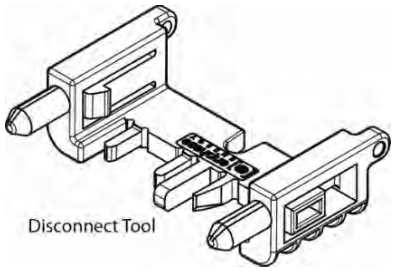
To ensure the microinverter is not disconnected from the PV modules under load, adhere to the following disconnection steps in the order shown:

1. Disconnect the microinverter AC connector from the Engage Cable.
2. Cover the module with an opaque cover.
3. Using a DC current probe, verify there is no current flowing in the DC wires between the PV module and the microinverter.

NOTICE

Care should be taken when measuring DC currents due to the fact that most clamp-on meters must be zeroed first and tend to drift with time.

4. Disconnect the PV module DC wire connectors from the microinverter.
5. Remove the microinverter from the PV array racking.
6. The microinverter connectors are tool-removable only. The installation kit includes a disconnect tool with two prongs. To disconnect a microinverter from the cabling system, insert these two prongs into the two holes in the cable connector. Squeeze the sides of the disconnect tool to engage with the connector. Rock the connector back and forth while pulling gently to disengage.



7. If the disconnect tool is not available, a #2 Phillips screwdriver can be used in its place. Insert the screwdriver into one hole, rock that side of the drop connector out, then insert the screwdriver into the other hole and pull the connector out entirely.

⚠ DANGER

Risk of Electrical Shock. Do not leave the drop connector uncovered for an extended period. If you do not plan to replace the microinverter immediately, you must cover any unused connector with a watertight sealing cap. Listen for two clicks as the connectors engage.

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Technical Data

Specification	Value
System temperature range (ambient)	-40C to +65C (-40F to 149F)
Cable temperature rating	90C Dry / 90C Wet
Cable insulator rating	THWN-2
Environmental protection rating	IEC 60529 IP67
UV exposure rating	UL 746 C, F1
Conductor gauge	12AWG
Maximum current carrying capacity of the Engage Cable	20 amperes
Maximum current carrying capacity of the drop cable (on the microinverter)	4 amperes
Cable bundle diameter	1.3 cm (0.525″)
Drop connector dimensions	11.8 cm x 6.0 cm x 3.2 cm (4.64″ x 2.36″ x 1.25″)
Terminator cap dimensions	3.6 cm diameter x 5.1 cm tall (1.4″ x 2″)
Cable weights [about 1lb (0.5 kg) per drop]: 30-drop cable 40-drop cable 240-drop cable	 30 lbs/14 kg (approximate) 40 lbs/18 kg (approximate) 240 lbs/110 kg (approximate)

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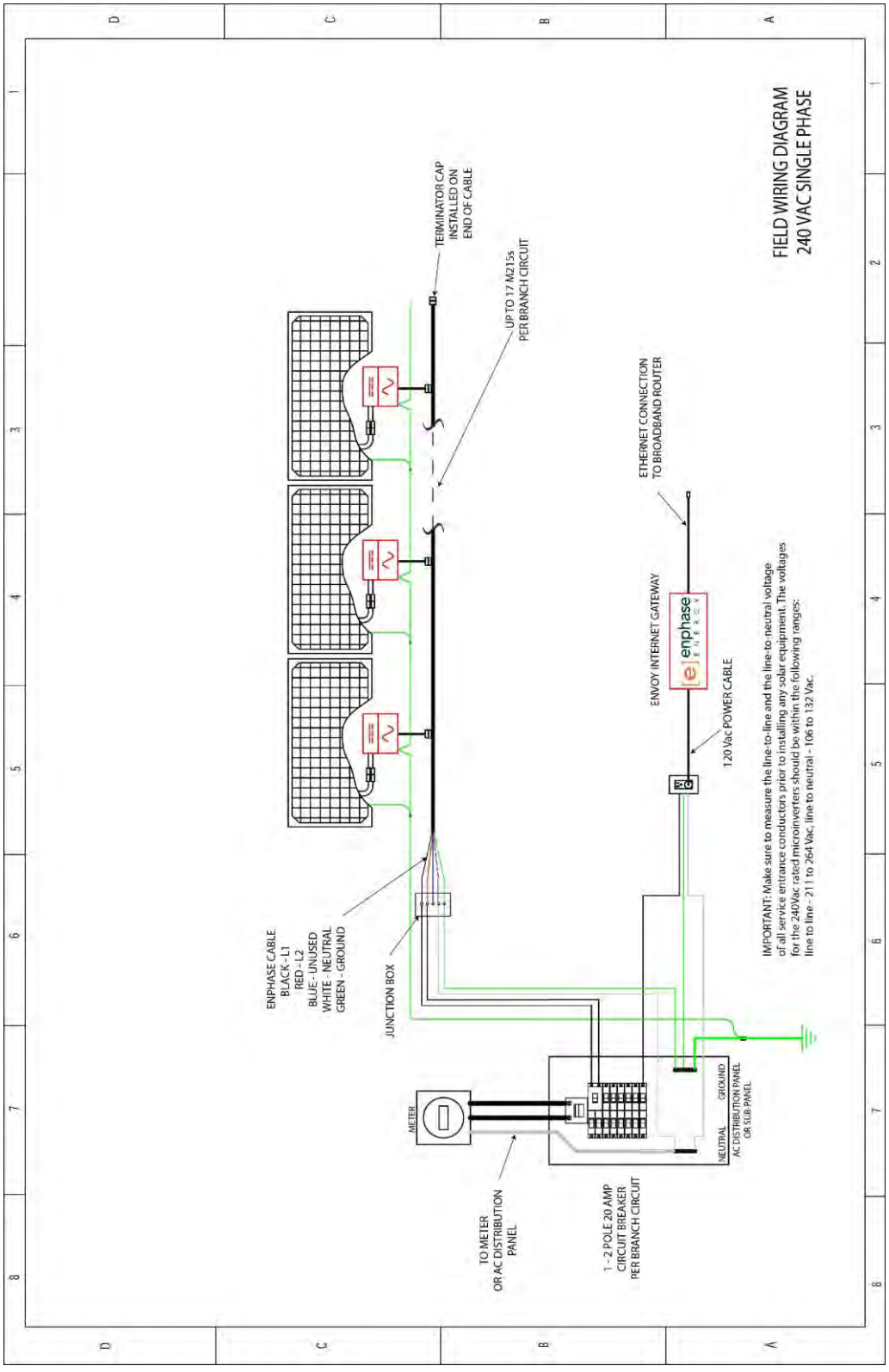
Appendix – Sample Wiring Diagrams

Sample Wiring Diagram – 240 Vac



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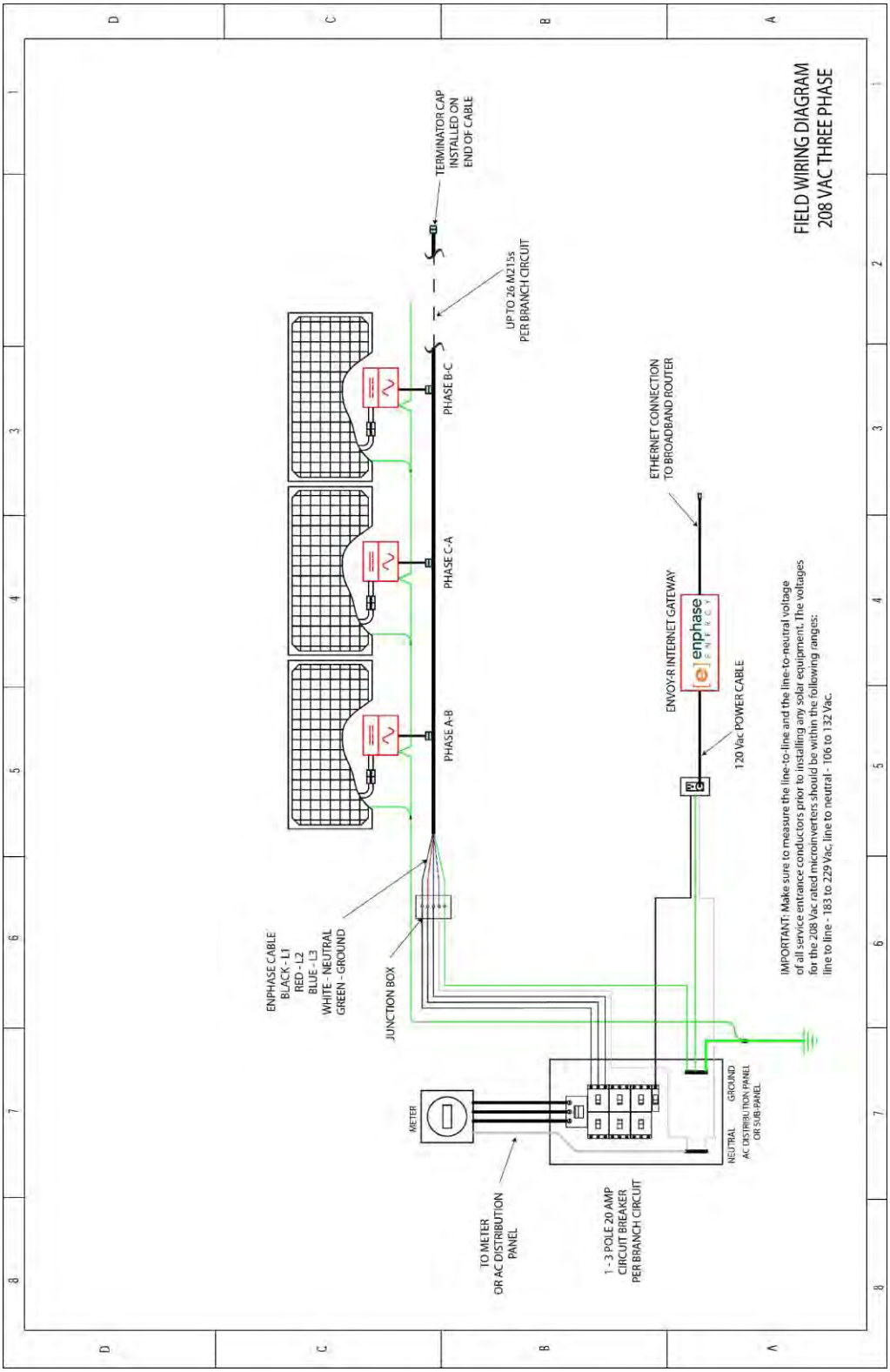
Sample Wiring Diagram – 208 Vac


FIELD WIRING DIAGRAM
208 VAC THREE PHASE
TERMINATOR CAP INSTALLED ON END OF CABLE
UP TO 26 M215s PER BRANCH CIRCUIT
PHASE B-C
PHASE C-A
PHASE A-B
ETHERNET CONNECTION TO BROADBAND ROUTER
ENVOY-R INTERNET GATEWAY
120 Vac POWER CABLE
ENPHASE CABLE
BLACK - L1
RED - L2
BLUE - L3
WHITE - NEUTRAL
GREEN - GROUND
JUNCTION BOX
METER
TO METER OR AC DISTRIBUTION PANEL
1 - 3 POLE 20 AMP CIRCUIT BREAKER PER BRANCH CIRCUIT
NEUTRAL
GROUND
AC DISTRIBUTION PANEL OR SUB-PANEL
IMPORTANT: Make sure to measure the line-to-line and the line-to-neutral voltage of all service entrance conductors prior to installing any solar equipment. The voltages for the 208 Vac rated microinverters should be within the following ranges:
line to line - 183 to 229 Vac, line to neutral - 106 to 132 Vac.

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info@enphaseenergy.com

Envoy Communications Gateway™

The Enphase **Envoy® Communications Gateway** provides network access to the solar array enabling comprehensive monitoring and management of an Enphase system.

Solar professionals and system owners can easily check the status of their Enphase System using the Envoy's LCD display or get more detailed performance data via Enlighten® Software, included with purchase of Envoy.

SMART

- Includes web-based monitoring and control
- Integrates with smart energy devices
- Automatically upgrades and sends performance data

SIMPLE

- Plug and play installation
- Flexible network configuration
- No additional AC wiring required

SCALABLE

- Residential or commercial ready out of the box
- Supports up to 600 microinverters

enphase® ENERGY

C US

INTERFACE	
Power Line Communications	Enphase proprietary
Local Area Network (LAN)	10/100 auto-sensing, auto-negotiating, 802.3

LAN CONNECTION OPTIONS	
Cable Assembly, Ethernet, RJ45, Orange, 10ft	Included with ENV-120-01 and ENV-120-02
Power line communication bridge pair	Included with ENV-120-01
Wireless N USB adapter (802.11b/g/n)	Included with ENV-120-02

POWER REQUIREMENTS	
AC supply	120 VAC, 60 Hz
Power consumption	2.5 watts typical, 7 watts maximum

CAPACITY	
Number of microinverters polled	Recommended up to 600

MECHANICAL DATA	
Dimensions (WxHxD)	222.5 mm x 112 mm x 43.2 mm (8.8” x 4.4” x 1.7”)
Weight	340 g (12 oz.)
Ambient temperature range	-40ºC to +65ºC (-40º to 149ºF)
Cooling	Natural convection—no fans
Enclosure environmental rating	Indoor NEMA 1

FEATURES	
Standard warranty term	Two years
Compliance	UL 60950-1, EN 60950-1, CSA22.2 No. 60950-1 and IEC 60950-1, FCC Part 15 Class B
API available	System-level production data

To learn more about Enphase Microinverter technology, visit **enphase.com**

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Appendix F – Fall Protection

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FREESTANDING COUNTERWEIGHT ANCHOR

Freestanding Anchor Does Not Require Attachment to Working Surface and Provides a Safe and Versatile Fall Arrest Rated Tie-Off Point!

- Non-penetrating design does not attach to the working surface, reducing the possibility of damage
- Built-in shock absorbing post provides added safety to user and structure
- Fall arrest and restraint rated for one worker for jobsite versatility
- For use in general concrete, steel or asphalt construction
- Approved for use on these roof types: concrete, single ply membrane, bitumen membrane, asphalt sanded and asphalt stone chippings
- Ideal for use on flat surfaces up to a maximum of 5 degrees slope/pitch
- Counterweights are 45 lbs. (20.3kg) and come with a integral carrying handle for easy transport and set-up

FREESTANDING COUNTERWEIGHT ANCHOR

Safe and Secure Anchor The freestanding counterweight anchor provides a tie-off point for personnel performing work on flat roofs or structures. The anchor is fall arrest rated and can be used as a single anchor point system. After set-up, simply attach your shock absorbing lanyard, self retracting lifeline or rope grab and lifeline and you are ready to go.

Non-Penetrating Design This anchor is a counterweight type, simply placed on top of the working surface. Weighted bases are added to rubber trays that are connected to a shock absorbing tie-off post. The anchor's freestanding design installs without penetrating the roof sheathing or surface, saving valuable time and money. In addition, the design reduces the possibility of surface damage, roof leaks and voided roof warranties.

Specialized Load Distributing Design This anchor incorporates a revolutionary shock absorbing system called LEAP™. The LEAP™ post (with tie-off point) has an integral energy absorber that deploys in a controlled manner to absorb the forces generated during a fall. This specialized design provides added safety to the attached worker and better distributes the forces to the anchor and structure. By limiting the forces this way, the integrity of the roof is also preserved.

Easy Installation Installation of the anchor system is simple, fast and efficient. Due to its modular design, the installer will never have to lift more than 45 lbs. (20.3kg). In some applications, the entire system can be lifted (by forklift or crane) into place for instant set-up and use. Refer to instruction manual for complete details.

Counterweight Anchor Models:

7255000: Freestanding Counterweight Anchor, includes sixteen 45 lb. (20.3kg) plates, roof post, base and D-ring

7200439: Single Counterweight Only, 45 lbs. (20.3kg)

Step 1

Align rubber trays into square pattern using notches

Step 2

Install the "L" bolts into the slots on the rubber trays

Step 3

Stack plates (weights) over bolts and onto rubber trays

Step 4

Set post and base onto the "L" bolts and plates

Step 5

Install the remaining four plates and tighten bolts/nuts

Specifications:

Counterweight Plates: Cast iron, galvanized ***Rubber Trays:*** Carbon steel, PVC coating ***"L" Bolts:*** Carbon steel, galvanized
Roof Post and Base: Post is painted stainless steel, the base is painted carbon steel ***D-ring:*** Forged steel, zinc plated
Standards: Meets EN 795:1997 Class E requirements.

Capital Safety
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Form: 9700153 rev: A

New!

MILLER Fusion™

Roof Anchor Post

Permanent or Temporary Solution for Roof Safety

- Versatile single-point anchor adapts to a wide range of roof designs
- Attachment to the roof surface is quick and easy reducing installation time by more than 50%
- Protects the worker by maintaining a secure connection to the structure in the event of a fall
- Protects the structure during a fall with a unique energy-absorbing load distribution system

INNOVATIVE ENERGY-ABSORBING DESIGN

MILLER® by SPERIAN

New!

MILLER Fusion™ Roof Anchor Post

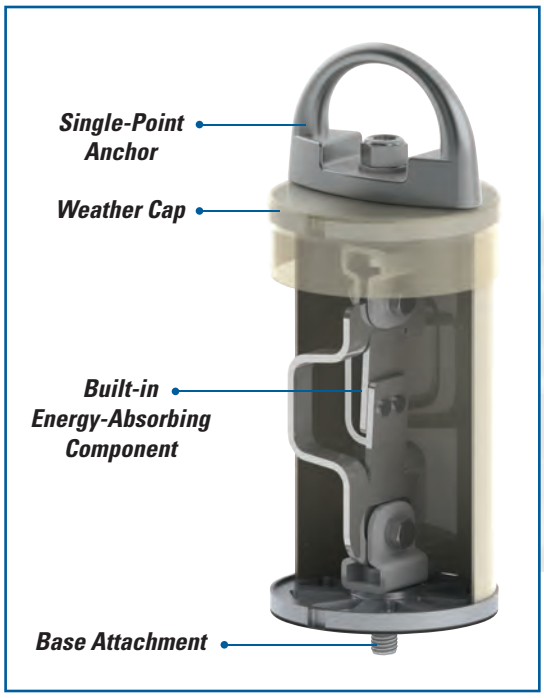
*The new versatile, single-point **Miller Fusion Roof Anchor Post** adapts to a wide range of roof designs with its innovative base plate engineered for temporary or permanent installation to the roof surface.*

When properly installed, a dependable fall protection connection is established. Should a fall occur, forces are reduced with its energy-absorbing design to maintain a secure connection to the structure.

*The easy-to-install **Miller Fusion Roof Anchor Post** is designed for quick set-up and does not require roof penetration to sub-surface rafters or trusses.*

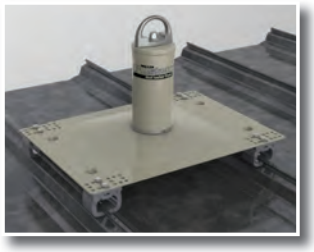
- **Versatile single-point anchor adapts to a variety of roof designs** – With a variety of models available, the Miller Fusion Roof Anchor Post can accommodate most industrial roof designs including standing seam, membrane, built-up, metal sheathing, concrete and wood.
- **Attaches to the surface of existing roof structures** – Quick, easy installation reduces cost requiring minimal labor and eliminating the need for roof penetration and repair.
- **Significantly reduces the fall forces on the roof structure** – In the event of a fall, the top of the Miller Fusion Roof Anchor Post reorients with the force in a direct line and activates the patent-pending energy absorber.
- **Durable design that withstands the changing outdoor environment** – Internal components are constructed of stainless steel. The steel post and base are plated with zinc followed by a premium powder coating for two layers of protection.
- Models for steel decking, concrete and wood can be used on other non-roof structures.

Modular bar extenders accommodate additional standing seam widths.



In the event of a fall, the Miller Fusion Roof Anchor Post orients in the direction of the force, the built-in, energy-absorbing component activates and the base remains securely attached to the roof surface.

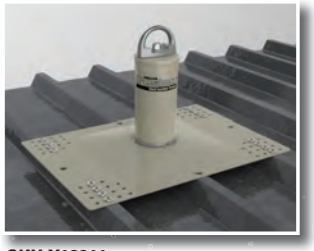
Miller Fusion Roof Anchor Post adapts to a variety of roof structures



SKU X10001

Standing Seam Design

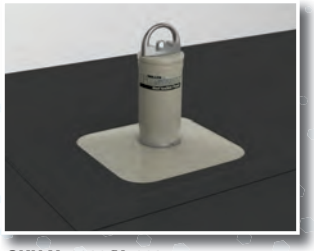
- Aluminum clamping mechanism is designed to pre-install to the base plate and is self centering for easy installation.
- The clamping bolts are tightened from above the plate for easy fastening and inspection.
- Can be used for permanent and temporary installations.
- Three models are available to accommodate standing seam spacing up to 24-inches *(610 mm)*.*



SKU X10011

Metal Sheathing Design

- Designed to attach to metal sheathing with a minimum 24 gauge *(0.024-inch [.61 mm])* thickness.
- Hardware kit includes sealing materials to prevent water damage to roof.



SKU X10030/X10031

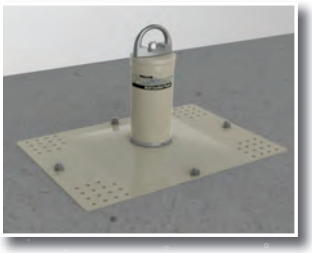
Membrane/Built-up Design

- Easy-to-install toggle kit fastens through membrane, insulation and into metal sheathing, wood sheathing or concrete.
- Models available for built-up roof thicknesses accommodate up to 10.5 inches *(267 mm)*.

SKU X10040

Wood Design

- Includes lag screw kit.
- Installs into plywood with minimum thickness of 5/8-inch *(15.9 mm)* CDX.
- *Designed for temporary installation only.*



SKU X10050

Concrete Decking Design

- Includes concrete expansion anchor kit.
- Installs into concrete decking with minimum thickness of 6.5 inches *(165 mm)* and minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*.

SKU X10020

Multi-Purpose Metal Sheathing, Wood and Concrete Design

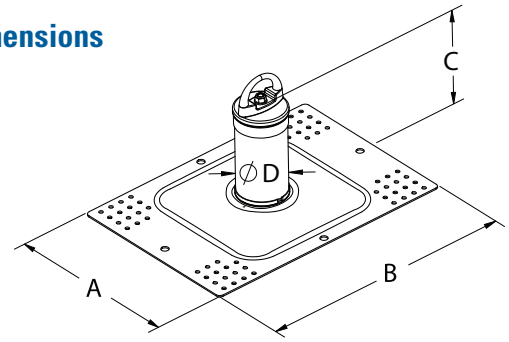
- This multi-purpose post uses the same base as models X10011, X10040 and X10050.
- Miller specified hardware must be purchased for this base. *(This model does not include hardware.)*

Applications

- *Roof inspection and maintenance*
- *Air conditioning, ventilation fan and solar panel maintenance*
- *Skylight cleaning*
- *Debris removal from gutters*
- *Installation and maintenance of satellite dishes and other communication systems*

**Complete list of models (SKUs) on back page.*

Dimensions



SKU	WIDTH A	LENGTH B	HEIGHT C	POST DIA. D
X10000 X10010	15.25 in. *(387 mm)*	18.0 in. *(457 mm)*	8.6 in. *(218 mm)*	4.0 in. *(102 mm)*
X10001 X10011 X10020 X10040 X10050		22.0 in. *(559 mm)*		
X10030 X10031			9.0 in. *(229 mm)*	
X10002	15.6 in. *(396 mm)*	26.0 in. *(660 mm)*	9.56 in. *(243 mm)*	

Specifications

Roof Anchor Post Materials

Energy Absorber:	Stainless Steel
Internal Connecting Components:	Stainless Steel
Top and Bottom Post Plates:	Anodized Cast Aluminum
Standing Seam/Wood/Metal Base Plate:	Two-layer Zinc/Powder-Coated Steel
Post Tube:	Zinc/Powder-Coated Steel
Post/Base Plate Seal:	HDPE
Post Cap:	Vinyl w/UV Inhibitor

Connection Components Materials

Standing Seam Clamps:	Anodized Aluminum/Stainless Steel
Extender Bar for Standing Seams:	Anodized Aluminum/Stainless Steel
Hardware for Metal Sheathing:	Hot Dip Galvanized/Neoprene
Hardware for Membrane:	Zinc-Plated Steel/PVC/Neoprene
Hardware for Wood:	Zinc-Plated Steel
Hardware for Concrete:	Stainless Steel

Performance

Activation Force:	1000 lbs. *(4.4 kN)*
Maximum Capacity:	310 lbs. *(140.6 kg)*

Fusion Roof Anchor Post

SKU	Description	Designed to Accommodate
STANDING SEAM ROOFING – Includes post with base and standing seam clamping assembly kit		
X10000	Small base	Standing seam spacing from 11.75 in. *(298 mm)* to 17 in. *(432 mm)*
X10001	Large base	Standing seam spacing from 11.75 in. *(298 mm)* to 21.25 in. *(540 mm)*
X10002	Large base & extension bars	Standing seam spacing from 11.75 in. *(298 mm)* to 24 in. *(610 mm)*
METAL SHEATHING ROOFING – Includes post with base and rivet kit with sealing washers and mastic tape		
X10010	Small base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])*
X10011	Large base	Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm]).* Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments.
MEMBRANE/BUILT-UP ROOFING – Includes post with base and toggle bolt kit		
X10030	Up to 5.5 in. *(140 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of up to 5.5 in. *(140 mm)*
X10031	> 5.5 in. *(140 mm)* & up to 10.5 in. *(267 mm)* thickness	Fastens through membrane, insulation & into metal sheathing, wood sheathing or concrete with a combined thickness of > 5.5 in. *(140 mm)* up to 10.5 in. *(267 mm)*
WOOD SHEATHING (TEMPORARY INSTALLATIONS ONLY) – Includes post with base and lag screw kit		
X10040	Wood sheathing	Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX
CONCRETE ROOFING – Includes post with base and concrete expansion bolt anchor kit		
X10050	Concrete	Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*
MULTI-PURPOSE METAL SHEATHING, WOOD AND CONCRETE ROOFING (NO HARDWARE INCLUDED) – Includes post with base. Hardware selection is based on the application. See instruction manual for hardware specifications.		
X10020	Metal sheathing, wood or concrete	• Metal sheathing w/minimum thickness of 24 gauge *(0.024 in. [0.61 mm])* • Trapezoidal spacing of 8 in. *(203 mm)* to 20 in. *(508 mm)* in one-inch *(25.4 mm)* increments. • Plywood with minimum thickness of 5/8-in. *(15.9 mm)* CDX • Concrete decking with minimum thickness of 6.5 in. *(165 mm)* & minimum concrete compressive strength of 3000 PSI *(20.7 MPa)*

Meets or exceeds all applicable industry standards including OSHA, ANSI A10.32 and Z359.1-2007.

This equipment should only be used after reading the manufacturer's instructions. Failure to follow instructions could result in serious injury or fatality.

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